SOAR
(Support Office for Aerogeophysical Research)

Annual Report
1996-1997

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Executive Summary

Overview.

The Support Office for Aerogeophysical Research (SOAR) is a facility of the National Science Foundation's Office of Polar Programs whose mission is to make airborne geophysical observations available to the broad research community of geology, glaciology and other sciences.

This facility grew out of science programs funded by the National Science Foundation beginning in 1989. The instrumented aircraft presently used by SOAR was also used for the site survey at the McMurdo Dome drill site and to collect ice thickness data across the West Antarctic ice streams. The support of these science programs and the increasing number of requests for access to an aircraft led to the concept of an aerogeophysical facility.

SOAR is a multi-institutional facility. The institutions with major responsibilities are the Institute for Geophysics at the University of Texas at Austin, Lamont-Doherty Earth Observatory of Columbia University and the Geophysics Branch of the U.S. Geological Survey. The central office of the SOAR facility is located in Austin.

This report summarizes the 1996/97 goals and accomplishments of the SOAR facility, its third year of operation and future facility plans.

History.

SOAR was chartered on August 1, 1994 via a cooperative agreement between the National Science Foundation and the University of Texas at Austin. The facility goal stated in the agreement is to "develop, maintain and operate a suite of geophysical systems aboard a Twin Otter Aircraft in support of research in Antarctica for five years."

In 1994, SOAR assembled a staff, designed the laboratory areas and deployed personnel and equipment for the 1994/95 Antarctic summer field season. SOAR executed a successful 1994/95 field season based out of Byrd Surface Camp in Marie Byrd Land, Antarctica, completing thirty-two survey flights equivalent to over 18,000 km of geophysical profiling. The primary science project supported was a collaborative aerogeophysics program of the University of Texas Institute for Geophysics, Lamont-Doherty Earth Observatory and the United States Geological Survey (CASERTZ/WAIS) over the West Antarctic Ice Sheet. The data acquired during the 1994/95 season also included the preliminary site selection information for the deep ice coring site at the West Antarctic ice divide. For the 1995/96 field season SOAR completed a successful eighty-eight flight operation again based at Byrd Surface Camp. The science projects supported were the CASERTZ/WAIS aerogeophysics program and, starting in that season, the glaciology program of the University of Wisconsin (UW). Details of the goals, accomplishments, finances and timetables of the 1994/95 and 1995/96 field seasons can be found in the respective SOAR Annual Report for each season.

Third Year Review.

Operations and Experiments.

The overall experimental goal of SOAR is to meet the scientific needs of its client science projects extending from initial proposal planning through detailed experiment design, data acquisition (field operations) and finally data management (data distribution, archiving and reduction). This year saw a significant expansion of SOAR's proposal planning activities. SOAR worked with investigators from ten institutions who developed seven proposals which were submitted to NSF for the June 1, 1996 deadline. Of these seven proposals, five are now slated to be flown by SOAR over the next two years. Detailed experiment design has begun for some of these projects.

For the 1996/97 field season the science project clients were CASERTZ/WAIS and UW. Seventy-two flights including seven reflights were anticipated to complete the project. The season was completed with fifty-eight flights due to efficiencies realized from a refined experimental design and the use of Upstream C field camp as a refueling site. Because of limited operational time due to poor weather and time lost due to use of the survey aircraft for a medivac, none of the planned reflights were flown. Ultimately, both the CASERTZ/WAIS and UW experimental objectives were accomplished and over 33,000 line kilometers of data was acquired.

The 1996/97 flights focused on operation over the Trunk of Ice Stream D (TKD of Figure 1). This was the final phase of the projects proposed by the CASERTZ/WAIS group and the UW groups. Representatives from both groups were in the field to perform quality checks of the data. All geographic goals for the 1996/97 season were accomplished and the overall data quality was good to excellent despite the lack of any flights dedicated to reflying survey lines of lesser quality.

Technology.

The technical goal of the facility is to prepare, configure and operate the geophysical and positioning systems aboard the survey aircraft to obtain the highest quality observations consistent with simultaneous operation of these systems. The geophysical instrument suite consists of a gravity meter, magnetometer, laser altimeter and ice-penetrating radar. The positioning suite consists of GPS receivers for navigation, GPS receivers for post-processed positioning (allowing differential carrier phase positioning), an inertial navigation system and a precision pressure altimeter. The geophysical measurements are time stamped with GPS time. Ground based instrumentation consists of base station magnetometers and GPS receivers. Ground computing facilities are utilized to download and quality check (QC) each flight's data within a few hours of landing. Various improvements were made to the aircraft and ground systems since the 1995/96 field season. These included developing a new system to improve the sampling speed and stacking depth of the radar digitizer, enhancement of the data acquisition system, improvement of precise aircraft navigation via real-time differential GPS and GLONASS technology and implementation of an in-flight radar monitor. Major repair and refurbishment targets included rebuilding the towed magnetometer systems, upgrading the download/QC workstations, replacing the CPU in the main acquisition computer, calibrating the electronic test equipment and replacing damaged shipping cases.

Logistics.

The SOAR facility has large and diverse logistical requirements. In handling these, SOAR was assisted by several organizations. The major needs and assisting organizations were:

- Aircraft Support -- operation and maintenance of the Twin Otter survey aircraft. Aircraft and services were contracted by Antarctic Support Associates (ASA) from Kenn Borek Air, Ltd.

- Field Support -- provided by ASA on-site at Siple Dome.

- Scientific Equipment Support -- the airborne gravity meter was supplied by the Naval Oceanographic Office (NAVOCEANO) and several GPS receivers were supplied by the University Navigation Consortium (UNAVCO).

- Cargo Support -- provided by a variety of groups involved in the transport of SOAR equipment coordinated by Lee Degalen for the NSF at Port Hueneme, California.

To meet its aircraft support needs SOAR requires exclusive use of the specially configured Twin Otter from the beginning of instrument installation to the conclusion of flight operations. Field preparation of the aircraft required twenty-five days this season, including nine test flights prior to regular survey flying. With the exception of reliability concerns with the autopilot and the Data Acquisition Interface (DAI), the aircraft and its subsystems critical to SOAR functioned well and were very reliable.

Field support consists of services provided principally for operation of the field camp. A special SOAR requirement is voice and data communications with North America. Low bandwidth communications were successfully established early in the season. This communications link proved inadequate to support transmittal of data to North America for remote QC review but was adequate for voice and email. The field camp and other field support proceeded smoothly throughout the season with the exception of the medivac.

External support supplying the GPS receivers and gravity meter has been required due to the expense of these instruments and the demand for their use by other research groups. UNAVCO supplied Turborogue GPS receivers. The gravity meter, a Bell Aerospace BGM-3, was supplied by NAVOCEANO. There was no backup for this device due to its expense.

Because of the need to transport a complete systems integration laboratory, a computing facility and the equipment necessary to operate the survey aircraft, SOAR requires a large amount of cargo. A total of 16,544 pounds of cargo was transported to Antarctica in eight shipments plus some items of handcarry. The shipping effort went very well this season with all items arriving as needed. As always, the gravity meter had special requirements, including an escort. This year the gravity meter and its SOAR escort experienced significant complications and delays during shipment in both directions. The process of shipping the gravity meter aboard military transport needs to be reevaluated.

Personnel.

The core staff of SOAR has stabilized at two directors, technical coordinator, science coordinator, research engineer, installation engineer, senior systems analyst, systems analyst and administrative associate. All these persons were with SOAR last year.

For the field deployment one additional person was temporarily hired, one was supplied by the United States Geological Survey, and NASA's Johnson Space Flight Center provided an engineer at no cost to SOAR to augment the core staff in the field. Expedition Computing Services (ECS), the field computing subcontractor, provided QC and data archival products in the field with a staff of three senior systems analysts and one systems analyst.

Oversight Committee.

The SOAR oversight committee was formed in 1995 and consists of:

- Robert Bindschadler (glaciologist), Goddard Space Flight Center, NASA.
- Terry Wilson (polar earth science), Department of Geology and Mineralogy, The Ohio State University.
- Terry McConnell (aerogeophysical operations), SCINTREX, Concord, Ontario.
- Jian Lin (marine geophysicist), Woods Hole Oceanographic Institution.

The oversight committee met in September 1996 to advise the facility on long and short-term directions. Their recommendations to SOAR covered a number of different topics such as project timing and selection, instrumentation, future improvements, proposal driven technology developments, data reduction efforts, long-term archiving and flight safety.

Finances.

Expenditures for SOAR during its second year (May 1, 1996 to April 30, 1997) are anticipated to be $862 thousand This compares to $1.044 million budgeted. The difference is primarily funding geodetic GPS receivers which has not been spent yet and unused salary for the augmented engineer supported by NASA.

Future Plans.

This section reviews issues and plans for SOAR in the upcoming years. Each general topic is fully described in the respective appendices.

Operations and Experiments.

The objective for SOAR for the 1997/98 field season is to acquire data for two glaciology programs of The Ohio State University, refly traverse routes in West Antarctica for NASA/Goddard, acquire data across the Transantarctic Mountains for investigators at Lamont-Doherty Earth Observatory and University of Texas at Austin and begin flying a survey in Marie Byrd Land for investigators from the University of California at Santa Barbara and Colorado College. The main base camp will be established at Siple Dome. Satellite operations will be necessary out of a camp in the downstream region of ice stream B (Downstream B) and South Pole. It is anticipated that up to seventy-nine flights will be required with field operations beginning in late October and extending through January. Fifteen SOAR personnel and two aircrews will be required to support this work.

SOAR will expand on its data management capabilities to encompass the reduction of data as requested by the proposals funded by NSF this year. Two data reduction specialists will be hired and trained while appropriate computing equipment will be obtained to meet the target of delivering reduced data nine months after the conclusion of the field season. SOAR is also planning to pursue a more proactive approach to project development. The goal of this effort is to allow the aircraft to be used in focused research areas by many scientists and to optimize international collaboration and logistical support.

Technology.

Because of the increased scope of SOAR's tasking, upgrades are planned for the data acquisition system and laboratory computer facilities as well as for the geophysical and navigation instrumentation. These improvements include: development of portable base stations, replacing the aging airborne magnetometers, replacing the existing DAI, developing specifications for a coherent radar system, improving the efficiency of the QC process through some software upgrades, acquiring spares for the precise aircraft navigation system, acquiring computing hardware for the data reduction effort and refining the overall QC system to take into account the increased level of airborne QC and the addition of the satellite base operations.

Logistics.

Future plans for SOAR logistics are guided by the desire to enhance existing arrangements and support new SOAR requirements.

Important items planned for aircraft support are the early field arrival of the survey aircraft next season, sufficient staffing and support equipment for aircraft operations away from the main base for up to seventy-two hours, the use of two aircrews, modification of spare antennas into an operational spare system, the use of a high-frequency receiver aboard the Twin-Otter to receive DGPS corrections, an improved autopilot system and assistance in the development of a SOAR safety procedures manual.

The plans for field support include early field arrival, satellite base operations and ATS (or better) voice and data communications.

For technical support the BGM-3 gravity meter will again be needed. In general, the gravity meter transport arrangements should be revisited. Other cargo requirements this year should be about the same as last year.

Personnel.

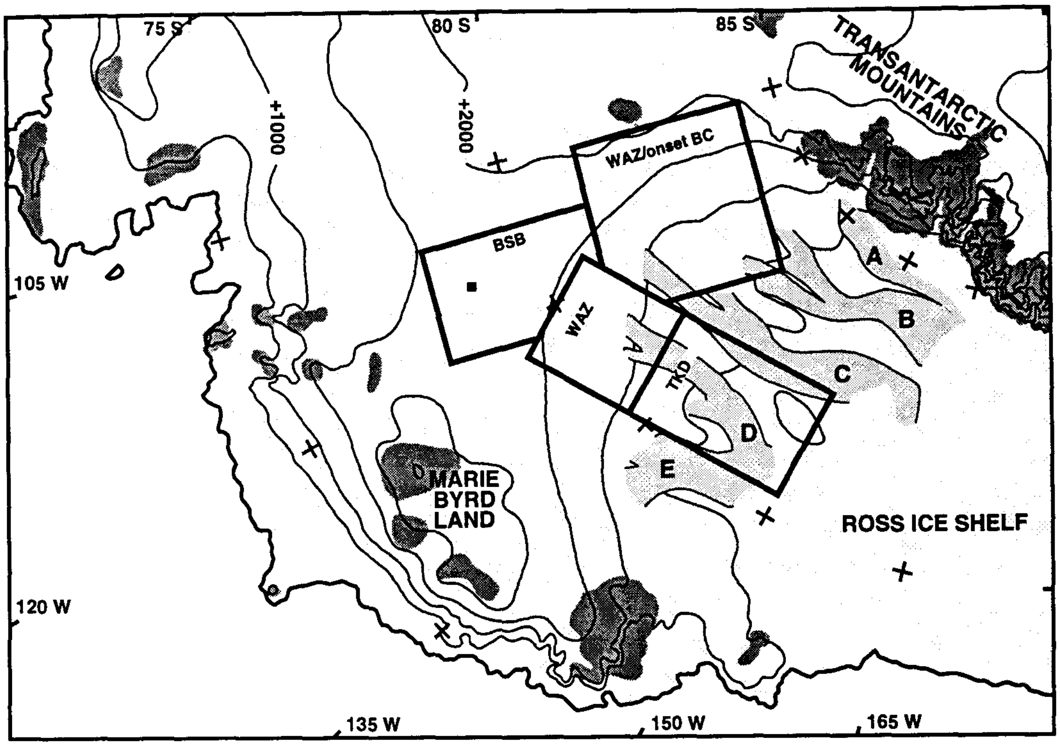
Significant changes in the SOAR staffing this year include the planned hiring of two data reduction specialists for reduction of the morphological, geopotential and positioning data acquired by the SOAR aircraft, and the planned hiring of a new engineer to enable the existing research engineer to specify a coherent radar design.

To reduce administrative costs, a software support contract will again be used for generation of quality control products and archives in the field. This subcontract eliminates the need to hire augmented systems analysts.

Finances.

SOAR expenditures for the coming year are anticipated to be increased over last year by the major initiatives of the data reduction effort and the specification of the coherent radar. Other expenditures should be in line with last year's. Some residual funds resulting from unexpected personnel support from NASA and delaying the purchase of GPS receivers will be reallocated to cover part of the new costs. Tradeoffs and tight budgeting will be necessary to support SOAR's ambitious tasking for the upcoming year.

(a)



(b)

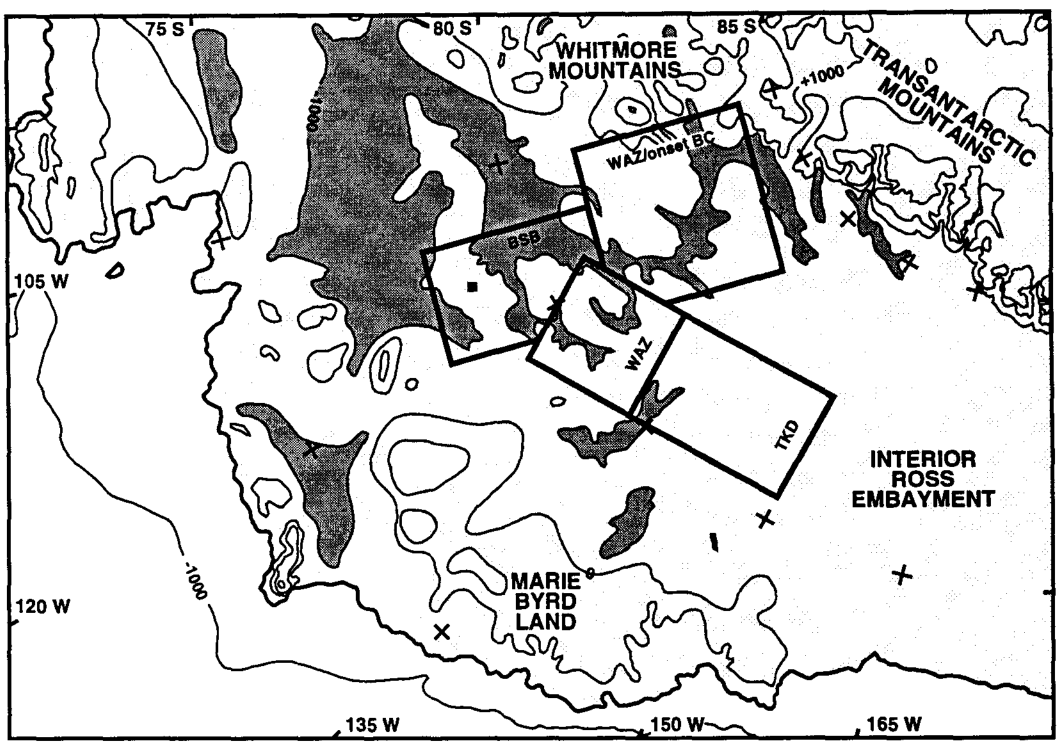


Figure 1 - SOAR survey targets shown on the surface and bedrock topography of West Antarctica. The three targets are outlined with blocks: [1] BSB (Byrd Subglacial Basin) [2] WAZ (Whitmore Accommodation Zone) [3] TKD (Trunk of Ice Stream D). The previously completed CASERTZ work is marked WAZ/onset BC. A small square marks the proposed WAISCORES deep-drilling site. Siple Dome, on the ridge between ice streams C and D, is the current site for the WAISCORES drilling effort. (a) Survey targets on the ice surface. (b) Survey targets on the bedrock topography.

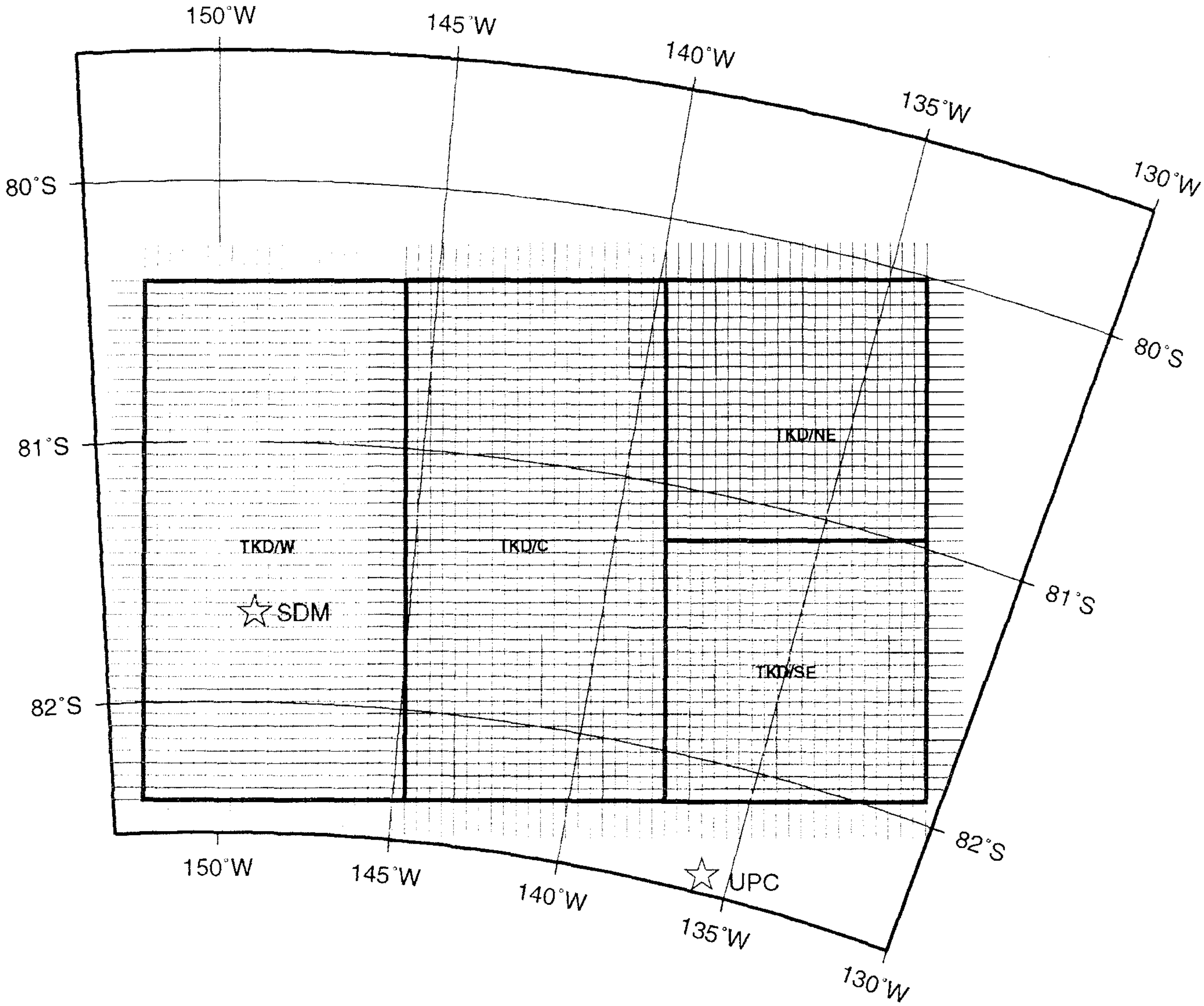


Figure 2 - SOAR survey coverage of the TKD target area during the 1996/97 field season. Stars indicate the position of Siple Dome (in the TKD/W block) and Upstream C (adjacent to the TKD/SE block).

Appendix A: Operations and Experiments
SOAR Annual Report
1996/97

This appendix details SOAR's support to experiments during the 1996/97 year and planned support for 1997-98. This year, the significant expansion in the facility's clients and proposed data products has warranted restructuring the Experiments Appendix into the following sections:

I. Project Development - facility support beginning with proposal development and planning and extending through detailed experiment design.

II. Data Acquisition - facility support of data acquisition centered around field activities.

III. Data Management - facility support of data distribution, data reduction and data archiving.

The overall experimental goal of SOAR is to meet the scientific needs of its client science projects extending from initial proposal planning through detailed experiment design, data acquisition (field operations) and finally data management (data distribution, archiving and reduction).

I. Project Development

Goal.

SOAR's project development goal is to provide support for developing proposals in a timely manner, with accurate estimates of the SOAR resources required to meet the experimental objectives of the science clients. SOAR's role in project development includes the detailed experiment design necessary to mesh the experimental goals of the funded science clients with the NSF logistics constraints.

Plans.

After the SOAR workshop held in March 1996, the Facility's objective was to work with investigators planning to use SOAR support in their science proposals both in clarifying SOAR capabilities and assessing SOAR requirements to meet their science goals.

Accomplishments.

SOAR assisted in the preparation of seven proposals which were subsequently submitted to NSF. The science coordinator worked closely with the principal investigators to outline operational constraints and to define the facility resources required to execute their proposed work. SOAR's product to the investigators at this stage was a statement of the facility resources necessary to support their proposal. Included in the resources statement was an Overview of the Proposed Work to ensure that the investigators and the SOAR staff had agreed on both the experimental targets and the most efficient experiment design. A Resource Summary Table outlined the days required, the number of flights, the number of line kilometers and the potential bases of operation required to complete the work. Specific comments as to data products requested, filling of the science observer role and special aspects of the experiment design were included in the Overview. An example of the Overview and Resource Statement from one of the proposals is included below in Tables A.1 and A.2. These resource statements were included in all proposals submitted to NSF.

Table A.1
Example of SOAR Overview of Proposed Work.

SOAR Overview of Proposed Work

Proposal: "Air-ground study of tectonics at the boundary between the eastern Ross Embayment and western Marie Byrd Land, Antarctica: Basement geology and structure, and influences on West Antarctic glaciation"

The proposed work entails collection of airborne gravity, magnetics, and laser altimetry data during the 1997/98 field season over a 440 x 480-km area in western Marie Byrd Land including the Edward VII Peninsula, Ford Ranges and Shirase Coast [A]. A portion of the study area is off-shore [B, C].

The objective of this work is to map basement structure and ice thickness for tectonic analysis [D]. The basement features are mainly crystalline rock and the area exhibits Basin-and-Range style topography with wavelengths of 15-km or more [E].

SOAR Comments

A. Science Observer. The investigator will be invited to participate in the Experiment Design and Support (EDS) group prior to and during deployment to the field.

B. Over-Water Flying. SOAR off-shore survey coverage will be limited to flying over annual ice suitable for landing a Twin Otter. Over-water flights will be limited to transits within gliding distance of a landing area.

C. Base-of-Operations. A base-of-operations will be required near the center of the proposed survey area.

D. Data Products. The data products to be delivered to the investigators are assumed to be reduced transect products including surface elevation, ice thickness, base-corrected magnetic field strength and free-air gravity registered to differential carrier-phase GPS positions.

E. Survey Coverage. In consultation with the investigator, the study area has been subdivided into sixteen 111.3 x 111.3-km blocks. Thirteen of these blocks are included in this proposal. Three of these blocks along the western edge of the study area, and one block in the southeast corner of the study area are to be flown with a 5.3 x 15.9-km line spacing. Three off-shore blocks (two to the east and one to the west of the Edward VII Peninsula) are off-shore and are given lowest priority. The remaining nine blocks are to be flown with 10.6 x 10.6-km a line spacing.

Table A.2
Example of SOAR Resource Statement

SOAR Resource Statement

Proposal: "Air-ground study of tectonics at the boundary between the eastern Ross Embayment and western Marie Byrd Land, Antarctica: Basement geology and structure, and influences on West Antarctic glaciation"

The study area includes thirteen 111.3-km blocks. Four of these blocks are to be flown with a 5.3 x 15.9-km line spacing. Nine blocks are to be flown with a 10.6 x 10.6-km line spacing.

The proposed work entails flying 44,218 line-km of survey lines and will require eighty-five survey flights. At a rate of 1.5 flights per day, the survey will require 75 days to complete and will span two field seasons. However, at 2.5 flights per day, the survey will require 45 days and can be accomplished in a single season. These estimates do not include time or flights required to configure and test the aircraft.

This estimate assumes 15.9-km run-ins/outs added to each line, 4 lines/flight, 10% reflights and 33% added in days for weather contingencies. It also assumes a base-of-operations located near the center of the proposed survey area.

The sustainable rate of flying using a single flight crew is 1.5 flights per day. Two full flight crews are required for 2.5 flight per day operations.

Data reduction requirements for this project will be based on the following transect products: surface elevation, ice thickness, magnetic field strength and free-air gravity.

Seven proposals requesting use of the facility were ultimately submitted to NSF by June, 1996. These proposals requested approximately 323 survey flights beginning with the 1997/98 field season. Both glaciological and geological studies were proposed although the geological studies were more regional and consequently requested a larger number of flights. Several of the proposed field programs spanned multiple field seasons. Institutions submitting proposals requesting SOAR support were:

Byrd Polar Research Center, The Ohio State University
The Colorado College
Lamont-Doherty Earth Observatory of Columbia University
Institute for Crustal Studies, University of California, Santa Barbara
NASA/Goddard Space Flight Center
National Snow and Ice Data Center
The University of Texas Institute for Geophysics
Saint Olaf College
University of Maryland
U.S. Geological Survey

After the NSF proposal review process the following five proposals were funded:

- "Air-ground study of tectonics at the boundary between the eastern Ross Embayment and western Marie Byrd Land, Antarctica"
- "Laser Altimetry for Ice-Sheet Volume-Balance: A use of the SOAR facility"
- "Contrasting Architecture and Dynamics of the Transantarctic Mountains"
- "West Antarctic Glaciology-V"
- "Stress Transmission at Ice-Stream Shear Margins"

Following the NSF funding decisions SOAR worked with the funded science clients to develop a refined experiment design.

The major experimental design accomplishments for these newly funded programs included:

- Working with Bruce Luyendyk of UC Santa Barbara and Christine Siddoway of Colorado College to develop an experiment design which optimized the available flight time to meet their science priorities in Marie Byrd Land. The resultant design targets the highest priorities areas with a total of sixty-three.
- Developing a revised estimate of the SOAR resources required for all the funded programs considering the detailed requirements of meshing multiple funded-programs. These revised flight numbers were forwarded to NSF and have been integrated into SOAR's planning and Future Targets for Data Acquisition (see below).
- Planning and completion of two test flights this season for the Laser Altimetry and Ice Sheet Balance study proposed by Ian Whillans. Two test flights during the 1996/97 field season (TF08, TF10) were dedicated to extensive testing of the SOAR laser altimetry system in support of this project.

For the 1996/97 season, SOAR had two clients: CASERTZ/WAIS (Corridor Aerogeophysics of the Southeast Ross Transect Zone-West Antarctic Ice Sheet) and the University of Wisconsin-Madison (UW). The CASERTZ/WAIS investigators are D.D. Blankenship, R.E. Bell, J.C. Behrendt and C.A. Finn. The UW-Madison investigator is C.R. Bentley. The experiment design for these experiments was completed in late 1996 in collaboration with representatives from the science programs and SOAR Experimental Design and Support group (EDS). For these previously funded programs, the EDS group merged the requirements of both projects into a single integrated experiment plan.

Issues to Address.

Project Development in Light of Limited NSF Resources: To date project development has emerged from primarily individual investigator initiatives. In light of limited NSF resources a strategy should be developed which optimizes the use of the SOAR platform by providing the maximum amount of data to the largest number of investigators.

International Collaborations: For the SOAR platform to be used most effectively, international collaboration may be necessary to address science targets in logistically difficult areas.

Dissemination of SOAR Capabilities: To ensure wide-spread use of the SOAR platform by a variety of investigators a strategy must be developed to disseminate information regarding SOAR capabilities beyond the current user base.

Future Targets.

Individual Investigators.

SOAR will continue to work with individual investigators to clarify SOAR's capabilities for data acquisition and data management as well as to assist them in assessing the SOAR resources needed to meet their science goals.

Project Coordination Role for SOAR.

Because of limited NSF resources, a strategy should be developed to optimize the use of the SOAR platform by providing the maximum amount of data to the largest number of investigators. To date the development of SOAR programs has been entirely reactive, in response to individual investigator proposals. We advocate a more proactive role for SOAR in proposal development. Like a major drilling ship, a satellite or an Arctic submarine cruise, use of the SOAR facility is optimized when the operations are in a focused location and when the data is being supplied to a broad range of investigators addressing a series of science problems. Because the SOAR platform was conceived as an interdisciplinary tool and interdisciplinary science inherently requires a high level of coordination, optimal use of the SOAR platform will require increased coordination. We suggest that for the next five years 2-3 target areas be proposed by the community as potential locations for SOAR centered campaigns. The process would involve developing science plans involving a broad suite of scientists for each of these targets. A suite of proposals would be submitted to cover the range of activities with the aerogeophysical work occurring early in the plan. Examples of target areas include Pine Island Bay as an extension of the WAIS program, and the Gambertsev and Pensacola Mountain regions of East Antarctica. Ideally over the next five years a plan could be developed for two major programs using 1-2 years of aircraft time each. The data from these programs would be utilized by many investigators. While these programs would target areas of interest to a broad range of scientists, sufficient flexibility should remain in the schedule to acquire data for smaller projects emerging from the existing strong pool of individual investigators.

International Collaborations.

For the SOAR platform to be used most effectively, international collaboration may be necessary to access logistically difficult areas. The goal is to enable US investigators to be more productive by capitalizing on the efficiencies gained from international collaboration. We propose developing a SOAR coordination role with other international Antarctic programs to enable the development of US science programs in these logistically difficult areas. Potential activities would include: workshops bringing in the international community of Antarctic geoscientists and glaciologists interested in collaborative programs; a clearer SOAR presence at ongoing compilation efforts such as ADMAP and BEDMAP; and attendance at SCAR meetings to present this concept to the appropriate working groups such as geology, glaciology and solid earth geophysics as well as the appropriate Groups of Specialists.

Dissemination of SOAR Capabilities.

SOAR should better publicize its technical and coordinating capabilities within the Antarctic science community and consider actively publicizing its capabilities beyond the Antarctic science community. Examples of such activities might include additional workshops, SOAR booths at AGU and GSA, presentations at NSF to program managers beyond Antarctic program managers and further development of the SOAR web page. A small increase in the scope of our administrative associate's tasking will be required for these activities.

II. Data Acquisition

Goal.

SOAR's data acquisition goal is to meet the experimental needs of the science clients by providing simultaneous observations of gravity, magnetics, ice-surface topography and subglacial topography. When the prime experimental objective is a subset of these data sets, SOAR aims to maintain the data quality of the secondary data sets wherever possible without compromising the primary data sets required by the science clients.

Over the course of their experiment the CASERTZ/WAIS investigators required aerogeophysical data in three adjacent regions of central West Antarctica (see Figure 1). The regions are:

BSB: the ice divide which overlays the Byrd Subglacial Basin.
WAZ: the onset of ice stream D which overlies the lithospheric "accommodation" zone between the Byrd Subglacial Basin and the Interior Ross Embayment.
TKD: the trunk of ice stream D in the Interior Ross Embayment.

For the 1996/97 season SOAR supported the CASERTZ/WAIS and UW-Madison projects mentioned earlier.

The UW-Madison study area was a subset of the WAZ and TKD regions. A portion of the data collected in these two regions will be used jointly by CASERTZ/WAIS and UW-Madison. The science objectives of these researchers required SOAR to complete an aerogeophysical survey of a 200,000 square kilometer region using an orthogonal survey grid with a 5.3 kilometer line spacing. This work was proposed to span three field seasons and was completed as planned this season.

Plans.

During the 1996/97 field season, SOAR's objective was to complete the TKD survey adjacent to the WAZ survey of 1995/96. The field plan required seventy-two survey flights based out of Siple Dome Camp.

Accomplishments.

Completion of TKD. The TKD survey was completed with fifty-eight flights summarized in Table A.5. Fewer flights than planned were completed due to more efficient flights and losses of potential flying days. The greater efficiency factors were: the availability of Upstream C camp as a hot refueling stop during flights in the east end of the survey area, the aircraft fuel usage sometimes allowed longer than planned flights and the combination of adjacent survey blocks into double-sized blocks. Tables A.6. and A.7. summarize the data quality obtained for each transect within the survey region. No dedicated reflights were flown this year because of poorer than anticipated weather and a medivac which reduced the number of flyable days.

During the field season, participants from both science clients monitored their experiment's progress. UW-Madison provided a dedicated science observer in the field during the data collection.

Issues to Address.

<u>Multiple operating areas.</u>
Use of the SOAR facility to support the new proposals will require operations from multiple bases during a season. This results both from small projects that are not geographically co-located as well as from large projects with an area of interest too great for efficient coverage from one base.

<u>Variable flight numbers in a season.</u>
Due to weather, and other factors, it is impossible to predict exactly how many flights will be successfully executed by SOAR in a given season. Thus for effective operations it is necessary to have the flexibility required to accomplish project requirements with uncertain

numbers of flights in a season. This implies a good prioritization scheme for flight execution.

Science observers.
With the increasing number of science projects the number of science observers in the field could begin to have a significant impact on logistics and SOAR operations.

Future Targets.

A plan for the next two years which accomplishes the funded projects and addresses the new issues listed above is presented in the following paragraphs and table.

The two-year operations plan depends on three new concepts including:

Dedicated Projects. Fifty-five flights per season are allocated to "dedicated projects" which are primary goals for the season.
Bonus Projects. Approximately twenty additional flights are allocated to "bonus projects". This gives a season flight total of about seventy-five.
Bases of Operation. Support is provided each season from a "main" base and a number of designated "satellite" bases. A main base supports aircraft configuration and provides normal camp support facilities. A satellite base may provide fuel, a geophysical base station, limited QC capability and/or berthing.

Table A.3 gives planned flights for the next two field seasons. The acronyms used are:

DCX = Dome-C extension to TAM-Wilkes corridor
DNB = Downstream-B
IMP = Italian Midpoint (fuel stop) between Dome-C and Terra Nova Bay
LIV = "Laser altimetry for ice-sheet volume-balance", Whillans and Csatho.
MBL = "Air-ground study of tectonics at the boundary between the eastern Ross Embayment and western Marie Byrd Land, Antarctica...", Luyendyk and Siddoway.
MCM = McMurdo (Williams Field)
NPX = South Pole Station
SDM = Siple Dome Camp

STI = "Stress Transmission at Ice-Stream Shear Margins", Whillans and van der Veen.

TAM = "Contrasting Architecture and Dynamics of the Transantarctic Mountains", Bell et al.

WAG = "West Antarctic Glaciology-V", Bindschadler et al.

Science observers.

SOAR will request that each project be limited to a single science observer, rather than having each institution provide a science observer. For 1997/98 this should reduce the maximum number of possible science observers from six to four. SOAR will develop a schedule for these science observers that attempts to place them in the field during the flying for their specific project while minimizing the impact on SOAR operations. Due to uncertainties in the weather the planned flight schedule may have to be modified. In this case, the SOAR priority will be to accomplish the season's flight program even if the appropriate science observer is not present. SOAR will provide e-mail support for the science observers, but no additional computing or engineering support will be available.

III. Data Management

Goal.

SOAR's data management goal is to efficiently distribute, archive and reduce the data acquired using the SOAR aircraft.

Plans.

The target date for distribution of the raw data from the 1995/96 season was August 1, 1996. SOAR began planning to supply some reduced data products to clients after the 1997/98 season.

Table A.3
SOAR Field Plan for 1997/98 and 1998/99.

Season: 1997/98
Main Base: SDM

Experiment	Primary	Bonus	Satellite Bases
TAM-Pensacola	28		NPX, DNB
LIV	11		DNB
WAG	9		DNB
STI	4		SDM
MBL	3		SDM
MBL		24	SDM
	55	24	79 Year's Total

Season: 1998/99
Main Base: MCM - Williams Field

Experiment	Primary	Bonus	Satellite Bases
MBL	36		SDM, MBL
TAM-DCX	12		Dome-C, IMP
TAM-Wilkes	6		IMP, MCM
WAG Reflights	1		SDM
LIV Reflights		11	SDM
TAM-Wilkes		10	MCM
TAM-Robb		3	
	55	24	79 Year's Total

Table Notes:

1. The TAM-Robb survey will require use of two Twin Otter aircraft: a utility Otter and the survey Otter. The utility aircraft will put in a fuel cache, mark an open-field skiway and call weather for the survey aircraft. The survey aircraft will transit into the survey region, fly one survey flight and transit out (total of three flights).
2. LIV work is limited to four survey targets requiring a single pre-survey calibration flight and ten survey flights.
3. The TAM-Wilkes work is to be completed in two phases: 1) a portion to be flown primarily from MCM and requiring operations from the IMP satellite base, and 2) a portion requiring only operations from MCM.

Accomplishments.

Data Distribution to Investigators for 1995/96. SOAR completed distribution of data from the 1995/96 field season to the CASERTZ/WAIS and UW investigators. The data products provided were raw digital data and hard copy quality control plots. The raw digital data were distributed by June 1, 1996. The paper QC plots were distributed in August, 1996.

Data from the test flight addressing Whillans' Laser Altimetry project was distributed on January 25, 1997.

SOAR developed a menu of data reduction products extending from the raw data now distributed to transect based products to map products. Prior to this year SOAR had exclusively dealt with distribution of raw data products. The resource statements developed for the 1996 proposal submission deadline requested both raw and transect based data products.

Issues to Address.

Starting with data acquired in the 1997/98 season SOAR has been tasked by NSF to supply data products reduced beyond the raw form presently distributed. This tasking will be a significant extension of SOAR capabilities and level of effort. The summary table of SOAR data distribution tasking (Table A.4) highlights this shift in products required by the science clients.

Table A.4
Data Management Tasking.

Data Product	Raw	Transect Morphology	Transect Geopotential	Map
Client				
CASERTA/WAIS	◆			
Glaciology	◆			
TAM	◆	◆	◆	
WAG		◆		
LIV	◆	◆		
MBL		◆	◆	
STI		◆		

At present SOAR has a general policy of "refreshing" the data it has collected on twenty-four month intervals but no external agency (e.g. NGDC or NOAA) presently archives SOAR data. This needs to be addressed.

Future Targets.

SOAR will establish an in-house data reduction capability starting in time to process the 1997/98 field data. The intention is to provide transect data products for the geomagnetic and gravity fields as well as surface and bed elevation. SOAR will continue to provide raw data products for each geophysical and positioning data stream when needed.

The specific plan is to hire and train two specialists this year who will be prepared to begin reduction of the 1997/98 data as soon as it is available following the field season. One data reduction specialist, the morphology specialist, will be focused on the morphology data, ice surface measurements and ice penetrating radar. The morphology specialist will train with the UTIG ice sheet morphology science program. The second specialist, a potential field specialist, will focus on navigation, magnetics and gravity data. This specialist will train primarily with the LDEO potential field group with some assistance from the USGS magnetics program. Minimal funds are requested for the CASERTZ/WAIS science investigators to support the training of these specialists. The targeted hiring date for these specialists is August 1, 1997 to permit six months of training prior to the arrival of data in February, 1998. A small budget for additional personnel to assist in the reduction of the 1997/98 data, beginning in February, 1998, is included. The SOAR computational framework required for these efforts is outlined in Appendix B: Technology.

In addition to the data reduction targets mentioned above, the SOAR directors will begin the process of arranging for an independent agency to archive SOAR data products.

Table A.5
Flight Operations Summary (1996/97 SOAR field season)

Flight Number	Date (NZDT)	Start Time (NZDT)	Duration (h:mm)	Flight Lines	Comments
TF01	22 Nov	15:24	4:05	-	Radar Test Flight
TF02	27 Nov	16:31	3:21	-	
TF03	30 Nov	11:11	2:20	-	
TF04	01 Dec	16:03	4:10	-	
TF05	03 Dec	16:17	3:03	-	
TF06	04 Dec	15:16	3:56	-	
TF07	06 Dec	15:30	3:11	-	
TF08	07 Dec	16:11	3:25	-	Laser altimetry test
TF09a	08 Dec	12:10	1:17	-	Land at Up-C
TF09b	08 Dec	14:20	3:56	-	Takeoff and land at Up-C
TF09c	08 Dec	20:10	0:57	-	Takeoff from Up-C
F01	10 Dec	07:35	3:18	4	
F02	10 Dec	14:16	4:39	5	
F03	11 Dec	01:12	3:26	4	
F04	11 Dec	07:53	4:34	5	
F05	11 Dec	14:19	4:20	5	
F06	12 Dec	01:02	4:03	5	
F07	12 Dec	07:31	4:32	5	
F08	12 Dec	14:08	4:35	5	
F09	14 Dec	01:04	4:48	6	
F10	14 Dec	07:44	4:27	5	
F11	14 Dec	14:16	4:09	5	
F12	16 Dec	01:59	3:27	4	
F13	16 Dec	07:41	2:02	2	Poor Weather
F14	16 Dec	13:27	2:18	2	Poor Weather
F15	17 Dec	14:08	4:28	5	
F16	19 Dec	01:57	3:28	4	
F17	19 Dec	07:13	5:52	6	Fuel at Up-C
F18	19 Dec	14:10	4:28	4	
F19	20 Dec	01:13	5:44	6	Fuel at Up-C
F20	20 Dec	07:58	4:25	4	
F21	20 Dec	14:05	4:08	5	
F22	21 Dec	01:08	3:46	4	
F23	21 Dec	07:33	4:26	6	
F24	21 Dec	14:06	4:27	4	
F25	22 Dec	01:20	5:36	6	Fuel at Up-C
F26	22 Dec	08:03	4:03	5	
F27	23 Dec	01:15	4:27	6	
F28	23 Dec	07:58	4:06	4	
F29	23 Dec	14:10	4:25	4	

Table A.5, Continued
Flight Operations Summary (1996/97 SOAR field season)

Flight Number	Date (NZDT)	Start Time (NZDT)	Duration (h:mm)	Flight Lines	Comments
F30	24 Dec	01:04	5:29	6	Fuel at Up-C
F31	24 Dec	07:43	4:33	6	
F32	24 Dec	13:20	3:50	4	
F33	26 Dec	07:44	3:07	4	
F34	26 Dec	14:04	4:24	4	
F35	27 Dec	01:17	4:03	4	
F36	27 Dec	08:22	3:41	4	
F37	28 Dec	01:09	5:31	6	Fuel at Up-C
F38	28 Dec	07:40	4:38	5	
F39	28 Dec	13:34	4:33	5	
F40	29 Dec	02:04	2:18	2	Poor Weather
F41	03 Jan	07:42	2:34	2	INS Failure
F42	03 Jan	14:05	1:57	2	Poor Weather
F43	04 Jan	01:13	5:33	6	Fuel at Up-C
F44	09 Jan	14:17	4:02	4	
F45	10 Jan	01:42	3:46	4	Poor Weather
F46	10 Jan	14:07	3:13	4	Poor Weather
F47	11 Jan	07:53	4:02	4	
F48	11 Jan	13:21	4:39	4	
F49	12 Jan	01:14	5:33	6	Fuel at Up-C
F50	12 Jan	07:43	4:11	5	
F51	12 Jan	16:22	3:03	3	
F52	13 Jan	01:12	6:16	8	Fuel at Up-C
F53	13 Jan	14:08	3:36	4	
F54	14 Jan	01:12	5:21	6	Fuel at Up-C
F55	15 Jan	08:08	3:38	5	
F56	15 Jan	13:37	4:30	5	
F57	16 Jan	01:14	3:54	4	
F58	16 Jan	07:36	3:52	5	
TF10	16 Jan	14:07	4:04		Laser altimetry test

Table A.6a
Data Quality Summary, Geophysical Systems: Gravity and Magnetics
(1996/97 SOAR field season)

	Gravity										Magnetics									
	NE		SE		C			W			NE		SE		C			W		
Line #	x	y	x	y	x	(x)	y	x	(x)	y	x	y	x	y	x	(x)	y	x	(x)	y
1	E	G	E	E	X	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E
2	E	E	G	E	G	E	E	E	E	E	G	E	E	E	E	E	E	E	E	E
3	E	X	G	E	G	E	E	G	E	G	E	E	X	E	E	E	E	G	E	E
4	E	G	G	G	G	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E
5	G	X	E	E	X	G	G	E	E	E	E	E	E	E	E	E	E	X	E	E
6	E	G	E	G	E	E	G	G	E	G	E	E	E	E	E	E	X	E	E	E
7	G	E	G	G	E	X	E	E	E	G	E	E	E	E	E	E	E	E	E	E
8	G	X	X	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E	E
9	E	E	E	E	X	G	G	G	E	G	E	E	E	E	E	E	X	E	E	E
10	E	E	G	X	E	E	G	G	E	E	E	E	E	E	E	E	E	E	E	E
11	E	G	X	E	X	G	E	E	X	E	E	E	E	E	E	E	E	E	E	E
12	E	G	E	E	E	G	X	X	X	G	E	E	E	E	E	E	E	E	E	E
13	E	G	E	G	G	G	G	E	G	E	E	E	G	E	E	E	E	E	E	E
14	E	E	G	G	E	E	E	G	G	G	G	E	G	E	E	E	E	E	E	E
15	G	E	G	E	G	E	G	E	G	G	E	E	E	E	E	E	E	E	E	E
16	E	G	G	E	E	G	G	E	E	E	E	E	G	E	E	E	E	E	E	E
17	E	G	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E	E
18	E	E	G	E	E	G	G	E	E	G	E	E	E	E	E	E	E	E	E	E
19	G	G	G	E	E	G	X	G	X	X	G	E	E	E	E	E	E	E	E	E
20	E	E	E	E	E	E	E	X	G	G	E	E	E	E	E	E	E	E	E	E
21	G	E	X	E	E	G	E	E	E	X	E	E	E	E	E	E	E	E	E	E
22	E	G	G	E	G	---	G	E	---	E	E	E	E	G	G	---	E	E	---	E

Note: E - excellent, G - good, X - bad
Lines in Wx, Cx, NE and SE are approximately 143 line-km in length.
Lines in Wy and Cy are approximately 254 line-km in length.
(x) = Summary for Wx and Cx lines 23 through 43 (Line # + 22)

Table A.6b

Data Quality Summary, Geophysical Systems: Radar and Laser (1996/97 SOAR field season)

	Ice-Penetrating Radar										Laser Altimeter									
	NE		SE		C			W			NE		SE		C			W		
Line #	x	y	x	y	x	(x)	y	x	(x)	y	x	y	x	y	x	(x)	y	x	(x)	y
1	G	G	E	E	E	G	G	E	E	E	G	E	E	E	E	E	E	X	E	E
2	G	G	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	E	E	E
3	E	G	G	E	E	G	G	E	E	E	E	X	E	E	E	E	G	E	G	E
4	E	G	E	E	G	E	E	E	E	E	G	E	E	E	E	E	E	X	E	E
5	G	E	E	E	E	G	E	E	E	E	E	G	E	E	E	E	G	E	E	E
6	G	G	E	G	E	G	E	E	E	E	E	E	E	E	E	E	E	E	G	G
7	E	G	E	G	E	E	E	E	E	E	G	E	E	E	E	E	G	X	E	G
8	G	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E	X	E	X	E
9	E	G	E	G	E	G	E	E	E	E	E	E	E	E	E	E	E	E	G	G
10	E	E	E	E	E	G	E	E	E	E	G	E	E	E	E	E	G	G	G	X
11	E	E	E	E	E	G	E	E	G	E	E	E	E	E	E	G	E	E	E	E
12	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	X	G	E	E
13	E	E	E	E	E	E	E	E	E	E	G	E	E	E	X	E	G	E	X	E
14	E	E	E	E	E	E	E	G	E	E	E	E	E	E	G	G	E	G	E	E
15	G	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E	G	G	E	E
16	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E	E	G	E	X	E
17	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E	G	E	E	E	E
18	E	E	E	E	E	E	E	G	G	G	E	E	E	E	E	E	G	E	E	E
19	E	E	E	E	E	E	E	E	G	E	E	E	E	E	E	E	G	E	X	G
20	E	E	G	E	E	G	E	E	G	G	E	E	G	E	E	G	E	E	X	E
21	E	E	G	E	E	G	E	E	E	G	E	E	E	E	E	E	E	E	E	G
22	E	E	G	E	E	---	E	E	---	G	E	E	E	E	E	---	E	E	---	E

Note: E - excellent, G - good, X - bad
Lines in Wx, Cx, NE and SE are approximately 143 line-km in length.
Lines in Wy and Cy are approximately 254 line-km in length.
(x) = Summary for Wx and Cx lines 23 through 43 (Line # + 22)

Table A.7a

Data Quality Summary, Positioning Systems: GPS and INS (1996/97 SOAR field season)

	Geodetic GPS										Inertial Navigation									
	NE		SE		C			W			NE		SE		C			W		
Line #	x	y	x	y	x	(x)	y	x	(x)	y	x	y	x	y	x	(x)	y	x	(x)	y
1	E	E	G	E	E	E	E	G	E	G	E	E	E	E	E	E	E	E	E	E
2	E	E	E	E	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E
3	E	G	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
4	E	E	G	E	G	G	E	G	X	E	E	E	E	E	E	E	E	E	E	E
5	E	E	E	G	E	G	E	E	E	E	E	E	E	E	E	E	E	E	E	E
6	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
7	E	E	G	E	E	G	E	G	E	E	E	E	E	E	E	E	E	E	E	E
8	E	E	E	G	E	G	E	E	E	E	E	E	X	E	E	E	E	E	E	E
9	E	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E	E	E
10	E	E	G	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E
11	E	E	E	E	E	E	E	E	X	E	E	E	X	E	E	E	E	E	E	E
12	E	E	G	E	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E
13	E	G	E	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E
14	E	E	E	E	E	E	E	E	X	E	E	E	G	E	E	E	E	E	E	E
15	E	E	G	E	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E
16	E	G	E	E	G	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
17	E	G	G	E	E	E	E	E	X	E	E	E	E	E	E	E	E	E	E	E
18	E	E	G	E	E	G	E	E	G	E	E	E	E	E	E	E	E	E	E	E
19	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
20	E	G	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
21	E	E	G	E	E	G	E	X	G	G	E	E	E	E	E	E	E	E	E	E
22	E	G	E	E	E	—	E	E	---	E	E	E	E	E	E	—	E	E	E	E

Note: E - excellent, G - good, X - bad
Lines in Wx, Cx, NE and SE are approximately 143 line-km in length.
Lines in Wy and Cy are approximately 254 line-km in length.
(x) = Summary for Wx and Cx lines 23 through 43 (Line # + 22)

Table A.7b
Data Quality Summary, Positioning Systems: Pressure and Weather
(1996/97 SOAR field season)

	Pressure Altimetry										Weather									
	NE		SE		C			W			NE		SE		C			W		
Line #	x	y	x	y	x	(x)	y	x	(x)	y	x	y	x	y	x	(x)	y	x	(x)	y
1	E	E	E	E	E	E	E	E	E	E	G	E	E	E	X	E	G	X	G	E
2	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	G	E	G	E
3	E	E	E	E	E	E	E	E	E	E	G	X	E	E	E	E	G	E	E	G
4	E	E	E	E	E	E	E	E	E	E	G	E	E	E	G	E	E	X	E	G
5	E	E	E	E	E	E	E	E	E	E	E	G	E	G	E	G	E	E	E	E
6	E	E	E	E	E	E	E	E	E	E	G	E	E	E	E	E	E	G	E	G
7	E	E	E	E	E	E	E	E	E	E	G	E	E	E	E	E	G	X	G	G
8	E	E	E	E	E	E	E	E	E	E	E	G	E	G	E	G	X	E	X	E
9	E	E	E	E	E	E	E	E	E	E	E	G	E	E	E	E	E	G	E	G
10	E	E	E	E	E	E	E	E	E	E	G	E	E	E	E	E	G	G	G	G
11	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	E	E	E	E
12	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	X	E	G	E
13	E	E	E	E	E	E	E	E	E	E	G	E	E	E	X	E	G	E	X	E
14	E	E	G	E	E	E	E	E	E	E	E	E	E	E	G	G	E	G	E	E
15	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	G	E	G
16	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	E	X	E
17	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	E	E	E	E
18	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	G	G	E	G
19	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	E	G	E	X	G
20	E	E	E	E	E	E	E	E	E	E	E	G	G	E	E	G	E	E	X	E
21	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G
22	E	E	E	E	E	—	E	E	—	E	E	E	G	E	E	—	E	E	—	E

Note: E - excellent, G - good, X - bad
Lines in Wx, Cx, NE and SE are approximately 143 line-km in length.
Lines in Wy and Cy are approximately 254 line-km in length.
(x) = Summary for Wx and Cx lines 23 through 43 (Line # + 22)

Appendix B: Technology
SOAR Annual Report
1996/97

This appendix focuses on the facility's technical goals, plans, accomplishments, outstanding issues and future targets.

Goal.

The SOAR technical goal is to prepare, configure and operate the geophysical and positioning systems aboard the survey aircraft to obtain the highest quality observations consistent with simultaneous operation of these systems. This technical goal includes providing base station facilities and a computational framework for data reduction. The geophysical observations are gravity, magnetics, laser altimetry and ice-penetrating radar sounding. The positioning observations are GPS (including post-processed differential carrier-phase), precision pressure altimetry and inertial navigation.

Plans.

The plans for major technical improvements during the third year of facility operations were the following:

1. Improve the sampling speed and depth of the radar digitizer.

2. Improve the overall efficiency of the data acquisition, download and quality control (QC) process.

3. Complete the implementation of the real-time differential GPS (DGPS) system.

4. Extend acquisition software and hardware for better in flight quality control.

5. Purchase geodetic GPS receivers to eliminate the need to borrow systems from other organizations.

6. Establish a stable laboratory computing network.

Accomplishments.

Radar Digitizer.

The Digital Stacking Unit (DSU) used in the past was replaced this year by a device designated the Digital Signal Averager (DSA). The DSA hardware is an off the shelf unit sold by EG&G Instruments Corporation under the designation "Model 9826-250 High-Speed Real-Time Signal Averager". It consists of a pair of PC-AT boards which fit into two standard ISA slots on an IBM compatible PC. In the SOAR system they were plugged into the 486 computer, the core of the aircraft data acquisition system. Custom software was written in SOAR to operate the boards under the QNX OS on the acquisition machine. The DSA incorporated all of the radar digitizer improvements SOAR specified. The instrument captures every sweep of the radar at the normal pulse repetition interval (PRI) of eighty microseconds with full speed sampling at a sixteen nanoseconds sample interval over a full eighty microsecond sweep. In addition, the DSA consumes much less power and is more compact than the DSU. The DSA maximum speed of four nanoseconds per sample will permit future system extensions.

The DSA produced about 65% more radar data per flight than the DSU due to its ability to capture more radar sweeps per unit time. The DSU caught every other sweep while the DSA caught about five out of every six sweeps. To accommodate this increased data volume the field download and quality control computer systems were enhanced as detailed in the next section.

Data Acquisition Efficiency.

To cope with the increased data volume provided by the addition of the new radar digitizer and to implement the goal of overall process efficiency, the field download and quality control computer network hardware and software were enhanced.

The central improvement was the addition of a Sparc Ultra I workstation running the Solaris operating system. This more powerful machine was able to host almost all serial data download and QC functions without degradation of system performance. The radar data QC requires the Sun-OS operating system requiring a Sparc 5/110 workstation running Sun-OS on the network.

Another area of improvement was GPS download and QC. The addition of a Pentium laptop computer running Windows 95 allowed more direct flow of GPS data from the receivers to the network. Windows 95 made it possible to mount UNIX network disks from the PC and to interface with peripherals and software which would only run on a PC. This Pentium laptop computer failed during the season and was replaced with a 486 laptop which maintained the functionality with somewhat degraded performance.

With assistance from Gerry Mader at NOAA Geosciences Laboratory and Bob Arko at Lamont-Doherty the main GPS reduction program used in the field, K&RS, was moved from MS-DOS to UNIX. Efficiencies arose from eliminating the need to transfer GPS data between DOS and UNIX environments and the increased speed of the UNIX platform for GPS QC. The QC products themselves also were improved in the field to indicate cycle slip events, which are indicative of degraded GPS data.

Precise Aircraft Navigation.

Two approaches were pursued this year to accomplish the goal of precision guidance of the survey aircraft. These were differentially corrected GPS and GLONASS/GPS.

Real-Time Differential GPS.

Real time positioning of the aircraft via differential GPS was implemented this season. A commercial DGPS aircraft positioning system (Trimble Navigation's TrimFlight) was used in the aircraft. This system includes a GPS receiver, moving map display and pilot's light bar. Differential correction data were generated by a fixed GPS receiver at Siple Dome Camp and uplinked to the aircraft via HF radio. A spare TrimFlight system was purchased before field deployment to ensure full backup capability for the system. The new system incorporated an improved GPS receiver and was upgraded with the newest improved moving map display in February 1997. Whether DGPS or GLONASS/GPS is used as the primary position source in the future, the TrimFlight will be used for display and user interfacing.

The HF uplink required considerable design and testing for this application. In order to avoid the "dead zone" normally encountered with HF communications at intermediate ranges a relatively low frequency was used (2.515 Mhz). At this frequency the ionosphere would normally reflect the signal back down at near vertical incidence and, given enough power, there is no "dead zone". SOAR normally transmitted DGPS corrections at 700 watts continuous power. This required a transceiver and two linear amplifiers in series. Several antennas were tried, including a conical-monopole and a commercial broad band dipole. The best antenna was a simple dipole constructed from wire and a balun.

The digital signal was encoded on the HF carrier by audio frequency shift keying -- a standard mode for HF digital links. The signal was received by one of the existing HF radios onboard the aircraft. For normal survey operations this radio was dedicated to continuously receive the differential corrections. In an emergency the radio could be used for standard communications without reconfiguration. An audio line-out connected to an HF modem linked to the SOAR equipment decoded the digital data.

This HF link proved reliable and could uplink to the aircraft anywhere in the survey area. Ionospheric conditions sometimes caused signal loss. Other outages were caused by minor hardware problems including a bad antenna cable. The estimated overall availability of differential corrections with this system was about 70% with the majority of the loss arising from poor ionospheric conditions. Improvements to this system are under consideration, including an increase in transmitted power and frequency diversity.

The navigational accuracy of the DGPS was measured by comparison of cross-track values recorded in real time with cross-track values calculated from the post processed differential GPS positions. These values generally agreed to within five meters.

GLONASS/GPS.

As a backup to the DGPS aircraft positioning system, a receiver which could use the Russian GLONASS satellites as well as the GPS satellites for real-time positioning was evaluated. The heart of this receiver was a new board which Ashtech, Inc. put on the market in 1996 designated the GG-24. The GG-24 can track twelve GPS satellites and twelve GLONASS satellites simultaneously and calculate positions from all the integrated data. There are three advantages this system has over standard GPS for real-time positioning:

1) Unlike the GPS signals available for civilian use, the basic GLONASS signals and resulting positions are not intentionally degraded. Thus raw GLONASS positions are about three times better than GPS (eight meter circular error probable for GLONASS versus twenty-five meters for GPS). This level of accuracy is usually sufficient to position the aircraft without differential corrections, thus precluding the need for the differential system.
2) GLONASS is a twenty-four satellite constellation. Together the GLONASS and GPS constellations provide a set of forty-eight possible satellites for use in navigation. In tests at Siple Dome Camp, the GG-24 regularly tracked seventeen to twenty satellites at a time.

3) The GLONASS satellites are in orbits of higher inclination than GPS so they get higher in the sky at polar latitudes than the GPS satellites.

Just prior to the field deployment, SOAR obtained a GG-24 board and fabricated a receiver for integration into the aircraft. The position data from the GG-24 was output as standard NMEA (National Marine Electronics Association) messages which were then input to the TrimFlight, bypassing its internal GPS receiver. These messages were also recorded as a matter of course whether they were going to the TrimFlight or not. As no active aircraft antenna for GLONASS was available at deployment time, a passive GPS antenna with some frequency ability in the GLONASS band was used with an in-line amplifier.

The GLONASS system was used several times during the season for aircraft navigation during test flights and survey operations. Early in the season the GLONASS system worked very well and positioned the aircraft almost as well or as well as the differential GPS. It was formally assigned to be used as a backup when the differential GPS was out. Later in the season it became unreliable for unknown reasons, showing many data drop-outs. The source of the drop-outs has not been determined but may be related to deterioration of connections to the GLONASS antenna that were inaccessable in the field.

From this year's experience a stand-alone GLOANASS/GPS system has the potential to replace the more complex DGPS system for aircraft real time positioning.

In-Flight QC Radar Monitor.

Software was implemented for the data acquisition system to display the output of the radar digitizer in real time. This provided in-flight diagnostic and monitoring capabilities for both the radar and digitizer. This radar monitor could display digitized radar returns in two forms -- either a time vs. amplitude plot, like an oscilloscope or a series of returns with the amplitude depicted by intensity variations in the displayed image.

GPS Receiver Acquisition.

SOAR acquired one Turborogue GPS receiver to complement the two currently owned by NSF-OPP. This is part of a plan to make SOAR more self sufficient in GPS receivers.

Repair/Refurbishment.

Major repair/refurbishment efforts for this year included the following:

1. Rebuild of two airborne magnetometer sensors. These systems proved unreliable this year despite the rebuild. The manufacturers have noted that the systems cannot be rebuilt again.

2. Memory upgrades to the Sun workstations of the field download/QC network.

3. CPU board replacements for the main aircraft acquisition computer.

4. Calibration of electronic test equipment.

5. Repair of damaged shipping cases. SOAR usually suffers about five events of "forklift penetration trauma" to shipping cases per year.

Issues To Address.

To achieve future experimental objectives the following technical issues need to be addressed:

Satellite Base Equipment. To accommodate operational base changes during future field seasons a suite of equipment which is easily transported must be developed. At minimum this "portable base" needs to provide ground based magnetic and GPS measurements and some level of data download/QC capability.

Computational Framework for Data Reduction and Distribution. SOAR has been tasked by NSF to deliver new processed data products. This capability will require the acquisition of computer workstations (as well as the personnel increases detailed in Appendix A.).

Magnetometer Replacement. The Geometrics 813 and 856 magnetometers used by SOAR are old and increasingly unreliable. Data was lost and many in-field (and in-flight) repairs were necessary. The SOAR Oversight Committee recommended an upgrade to an optically pumped cesium magnetometer system, or a three-component system, if technically feasible. The magnetometer systems must be upgraded.

Coherent Radar. In order to meet developing needs of the research community the ice-penetrating radar should have a coherent detection and stacking capability. This need was identified by the Oversight Committee last year. This year some preliminary hardware (new digitizer boards as used in the DSA) was identified for use in developing the coherent capability. A plan for complete implementation needs to be completed and executed.

Data Acquisition Interface (DAI). The single existing DAI 1200 supplied by the aircraft contractor to interface the aircraft INS to the SOAR acquisition system is becoming increasingly unreliable and cannot be maintained. SOAR needs to acquire new devices for this task.

Data Acquisition Efficiencies and Improvements. The field data acquisition computer systems require some improvements and additions. Currently the use of two different UNIX operating systems is necessary; Sun Solaris for most tasks and the older Sun-OS for the radar QC. This mixture of operating systems causes inefficient use of computing resources. Also the new computer additions, the Sun Ultra and Dell Pentium, do not have dedicated backups. For this year, contingency planning involved using rental machines and less capable loaners from other computer networks. Backups need to be acquired for these new machines.

Precise Aircraft Navigation. The DGPS and GLONASS/GPS aircraft navigation systems both povided positioning for the aircraft during the 1996/97 season. Each system has operational weaknesses. SOAR currently does not have a set of spares for either system (except the TrimFlight which is shared by both).

Integrated QC. Because of increasing aircraft autonomy, emphasis needs to be placed on upgrading in-flight QC and base QC systems.

Repair/Refurbishment. The most notable equipment failures which occurred in the field this year were multiple magnetometer failures and a few laptop failures including one laptop which literally emitted a wisp of smoke then failed in-flight. Repair and refurbishment efforts for these and other systems will have to be pursued to be ready for the next field season.

Geodetic GPS Receiver Suite. To outfit one main base, two satellite bases and the aircraft SOAR will require a total of ten geodetic GPS receivers for next season. This requirement breaks down as one Ashtech Z-12 and one Turborogue receiver in each of the aircraft and main base, two receivers (either vendor) in each satellite base and one spare of each type. SOAR currently owns three Turborogue receivers and no Ashtech Z-12s. Receiver purchases must be continued or increased reliance on loaned items will be necessary.

Future Targets.

1. Satellite Base Equipment. SOAR plans to develop a pair of portable base stations with the following capabilities in priority order -- GPS observations, acquisition system downloading (with some QC) and geomagnetic field observations. Major hardware required for a station would consist of two geodetic GPS receivers, a magnetometer and a computer workstation. The target is to acquire the hardware for two base stations with a budget limit of $10,000 for each (excluding GPS receivers).

2. Computational Framework for Data Reduction and Distribution. SOAR plans to acquire a dedicated workstation with peripherals for the two data reduction sites planned -- one for potential fields and GPS and one for surface and subsurface morphology. These computing assets will also be used to prepare data for distribution.

3. Magnetometer Replacement. SOAR plans to acquire two airborne cesium magnetometers and continue to investigate adding a three-component magnetometer capability.

4. Coherent Radar. The plan for development of coherent radar capability is to dedicate 0.5 person-year effort to evaluation of existing radar designs in 1997/98 with the goal of settling on a general specification. In the 1998/99 fiscal year the system will be built and prepared for field testing. The estimated cost for that year would be 1.25 person-years effort and $125,000 equipment costs. A subcontract for the construction of this equipment will also be evaluated.

5. Data Acquisition Interface. SOAR plans to fabricate or obtain two functional replacements for the existing DAI 1200.

6. Data Acquisition Efficiency. To address the inefficiencies and vulnerabilities of the field download and QC network a UNIX workstation and PC will be acquired. Also the existing radar QC program will be ported to the Solaris operating system.

7. Precise Aircraft Navigation. The experimental target for aircraft navigation is to fly within 22.5 meters of the planned flight line. This target is driven by current radar pulse width and processing considerations. To continue the development of robust precision navigation for the aircraft, critical spares for both the DGPS and GLONASS/GPS systems are to be acquired. The two systems provide independent cross checks of navigation under varied ionospheric conditions and survey flight plans.

8. Integrated QC. The plan to provide an integrated QC process across the three platforms of aircraft, satellite base and main base requires the integration of the varied QC functions required at each location.

a) The aircraft's QC systems (mostly software) will be upgraded to provide user friendly monitoring of data from each instrument in real time (in flight monitor function) along with trend displays of each data stream (the instrument QC display).
b) The satellite base station's QC capability will incorporate the checks of downloaded data's integrity and consistency as currently implemented for the main base systems, along with the K&RS processing of GPS data and the plotting of magnetics base station data. This allows the operator at the satellite base to confirm that the equipment at the satellite base is working properly and to confirm that the data recorded on the aircraft is complete and readable.
c) The main base QC may receive minor upgrades but no major changes are necessary.

9. Repair and Refurbishment. The primary focus for repair and refurbishment will be the network of laptop computers used for operation and monitoring of aircraft and base station data acquisition.

10. Geodetic GPS Receiver Acquisition. SOAR will purchase one Ashtech Z-12 GPS receiver and pursue borrowing the remaining GPS receivers from its home institutions (UTIG and LDEO) to cover its geodetic GPS receiver needs.

Appendix C: Logistics
SOAR Annual Report
1996/97

This appendix details the logistical support aspects of the facility's 1996/97 field season. It is divided into the following sections:

I. Aircraft Support - facility interactions with the aircraft contractor Kenn Borek Air, Ltd.

II. Field Support - facility interactions with Antarctic Support Associates (ASA).

III. Technical Support - facility interactions with organizations providing equipment and service directly to SOAR, specifically, the University Navigation Consortium (UNAVCO) and the Naval Oceanographic Office (NAVOCEANO).

IV. Cargo Support - facility interactions with NSF and ASA cargo systems.

I. Aircraft Support

The Twin Otter survey aircraft, flight crew and maintenance support in the field were provided by Kenn Borek Air, Ltd. of Calgary, Canada. This section discusses the facility's goals, plans, accomplishments, issues to be addressed and future targets as they pertain to the interactions with this contractor and the survey aircraft.

Goal.

SOAR's principle aircraft support goal is to receive the survey aircraft from the contractor, optimized to SOAR's specifications for use as an aerogeophysical platform, and after configuration and testing by SOAR personnel, operate it safely and reliably in the field during the survey period.

Plans.

To meet its aircraft support goal for the 1996/97 field season, the following items were identified in pre-season planning:

Modification of a second set of radar antennas for use on the existing Twin Otter platform. These antennas currently exist at the Facility, but require modification to their mountings for use with the current mounting system aboard the Twin Otter.

Two flight crews (four pilots) must be on-hand to support SOAR survey flights, along with six SOAR instrument operators to complete a seventy-two flight season lasting from late October 1996 to early January 1997. The planned flight rate is three survey flights per day.

Delivery of the Twin Otter to the SOAR field camp directly from Calgary, Canada.

Pre-deployment site visit to Kenn Borek Air, Ltd. by SOAR personnel to inspect aircraft fabrications and modifications and to verify SOAR specifications (see Table C.1).

Installation of a new HF antenna and receiver or enable an existing HF radio to receive the DGPS corrections and relay them to the DGPS aboard the aircraft.

Obtaining on-site spares of the critical contractor supplied systems and implementing a plan for a quick delivery of replacement aircraft parts (See Table C.1, Equipment Supplied by Kenn Borek Air, Ltd.). Of special interest are available spares for the Data Acquisition Interface (DAI) and Inertial Navigation System (INS).

Accomplishments.

This section focuses on the aircraft support accomplishments during the third year of the facility operations.

Prior to deployment, two SOAR personnel made a one-day Calgary visit on October 15. During this visit the signal cables for the ice-penetrating radar were installed in the wings. Also, the other aircraft cabling and modifications necessary for SOAR use were discussed with personnel from Borek and Western Avionics.

As required by SOAR, Borek provided an audio line-out from the aircraft's number two HF radio to the SOAR equipment. This line was used to receive differential GPS corrections and functioned well throughout the season. SOAR requires that this configuration remain available for future use.

Borek provided a static pressure connection to the co-pilot's static source. This was requested to evaluate if this source can be used for precision pressure altimetry instead of the dedicated pressure wand. The data from this source was recorded on test flights and will be evaluated after the season.

The aircraft arrived at Siple Dome Camp on November 13. The aircraft configuration and testing (including nine test flights) were completed in twenty-five days. An extended test period was required to integrate the new radar digitizer and DGPS systems. Configuration delays were encountered waiting on the gravity meter and magnetometer mounting plates to be delivered to Siple Dome.

Two full flight crews were provided in the field to support flight operations. Regular survey flight operations began on December 10 and continued until January 16, 1997. The Borek personnel assigned to support SOAR were very professional and helpful throughout the season.

Overall the Twin Otter and its subsystems critical to SOAR functioned well and were very reliable. The two systems which raised reliability concerns were the autopilot and the DAI (both discussed below in "Issues to Address").

Issues To Address.

In light of the recent poor safety record for worldwide aerogeophysical operations, SOAR in close cooperation with the aircraft contractor needs to carefully analyze its own operations from a safety perspective.

For the 1997-98 field season SOAR will begin operating in a mode that utilizes satellite base camps as well as a main base (see Experiments and Operations Appendix). This will impact the ground support for Twin Otter operations. This season's satellite bases will be South Pole Station (NPX) and Downstream B (DNB); the main base will remain at Siple Dome (SDM).

The autopilot suffered a failure early in the season which was quickly repaired; however, its flying control responses after the repair were somewhat different than before the repair. Specifically, for the rest of the field season, its altitude hold response required very close monitoring and some help by the pilots to hold altitude through a flight line.

There still is no spare or replacement for the DAI 1200 currently used and this unit has been suffering intermittent failures for the last two years. As proposed in the Technology appendix, SOAR will build a pair to its specifications in-house, and will require contractor support to interface this device to the various avionics systems.

The spare radar antennas have not been configured. It will also be necessary to have a set of spare antenna mounting struts fabricated in case of an accident involving these assemblies.

Future Targets.

To support next season's operations, a number of aircraft-support targets have been developed. They are:

Assistance to SOAR in the development of a safety procedures manual based on documentation available through the International Airborne Geophysical Safety Association (IAGSA).

Assuring availability of the support equipment and accommodations necessary to allow operations for seventy-two hours at each satellite base (NPX and DNB) without returning to the SOAR main base (SDM).

Aircraft autopilot repair or replacement to ensure the altitude hold requirement of +/-12 meters is met with the capability for response tuning in the field.

Obtaining on-site spares of the critical contractor supplied systems and implementing a plan for quick delivery of replacement aircraft parts (see Table C.1, Equipment To Be Supplied by Kenn Borek Air, Ltd.). Of special interest are available spares for the INS and autopilot and assistance to SOAR in its construction of new DAIs.

Having a complete set of ready-to-install spare radar antennas and struts. Existing spares should be adapted and new ones fabricated as needed.

A pre-deployment site visit to Kenn Borek Air, Ltd. by SOAR personnel to inspect aircraft fabrications and modifications and to verify SOAR specifications (see Table C.1).

HF receiver and antenna interfaces to pass DGPS correction data to the SOAR precision navigation equipment. Also mounting of the GPS/GLONASS antenna for precision navigation that enables servicing in the field.

Availability of two flight crews (four pilots) to complete a fifty-five to seventy-nine flight season lasting from early November 1997 through January 1998. The planned flight rate is three per day.

Table C.1
Equipment Supplied by Kenn Borek Air, Ltd.

GPS positioning * - CA code with latitude and longitude [±0.1 minute] available over an RS-232 port.

Inertial Navigation * - Litton LT-92R or equivalent with all raw binary output available for SOAR interfacing.

Pressure Altitude * - 0.5 m pitot boom and Paroscientific 1015a or equivalent with pressure [±0.1 mbar] over a range of 600-1100 mbar available over an RS-232 port.

Outside Air Temperature * - temperature [±1° C] over a range of -40° to +25°C available for SOAR interfacing.

Autopilot † - roll, pitch and pressure altitude stabilized with all controls available to both pilot and copilot. Altitude hold performance must attain ± 12 meters maximum excursions with the capability of tuning responses in the field.

Antenna system refurbishment and cable raceway in wings - for user-supplied radar antennas to be mounted beneath wings; includes flight preparation/relamination of user supplied antennas and struts, including modification and/or fabrication of spares.

Securing mechanisms and viewing window - for the "bird" containing the magnetometer sensor that is to be towed on a 30 m retractable cable and laser range finder which is mounted in viewport.

Auxiliary Power Units † - 28V at 10 kW. One APU is required at the main base and each of the satellite bases.

Intercom † - four operator headsets with push-to-talk and cockpit isolation features.

Precision Navigation Equipment Interfaces - HF Radio† with audio line output and antenna to receive DGPS correction signal. Field accessible mount for the GLONASS/GPS antenna.

Radar Altimeter * - altitude above surface (± 0.5m) over a range of 0 to 500 m available for SOAR interfacing.

* Engineering diagrams and manuals must be available in the field for these avionics systems.

† Spare parts, engineering diagrams and manuals must be available in the field for these systems.

Delivery of the Twin Otter to Siple Dome Camp directly from the contractor facility in Calgary.

II. Field Support

Field support includes services provided by ASA to the facility principally for operations of the field camp. This section focuses on these services.

Goals.

The goals of the SOAR field support efforts primarily are to ensure that the field camp is set up to optimize configuration and safe operation of the survey aircraft, and secondarily to minimize the time and resources necessary for field site setup and maintenance.

Plan.

The SOAR field support plan for the 1996/97 field season focused on ensuring that adequate services and communications were available for efficient aircraft configuration and safe flight operations. The plan included:

Occupying a field site at Siple Dome Camp, Antarctica by early November and departing this field site by the second week of January 1997.

ATS (or better) voice and data communications links be established at the field site prior to the arrival of SOAR field personnel.

Flight following capability with hourly updates from three locations during flight operations. Any nearby ASA-supported field camps must monitor radio traffic 24 hours per day.

Two alternate landing sites with fuel caches positioned at least seventy-five kilometers and no more than 200 km away from the base field site.

A DGPS radio tower capable of broadcasting a 2-3 Mhz signal to a range of 300 km located at the base field site.

Accomplishments.

The major field support accomplishments are given below.

Siple Dome Camp was occupied by SOAR personnel from November 6, 1996 through January 20, 1997. The SOAR science jamesway from Byrd Surface Camp was moved to Siple Dome. The facilities to support the planning, maintenance and survey environment (work benches, bookshelves, etc.) were available. Other camp facilities were available when needed to support aircraft configuration, testing and flight operations. After the completion of flight operations on January 16 three days were required for deconfiguring the aircraft and packing equipment. In general, the ASA personnel at Siple Dome did an excellent job of supporting SOAR operations throughout the season. In particular, the camp manager, Rich Flanders, was proactive and expert in ensuring SOAR's requirements for camp resources were met.

Prior to beginning the configuration of the Twin Otter for survey flying, the aircraft was used to put in one fuel cache. Another fuel cache placed near the survey area last year was found and inspected. These two plus the camp at Upstream C were sufficient emergency fuel stops to support survey operations.

The ATS satellite communications system used last year at Byrd Surface Camp was moved to Siple Dome. This system worked well and supported a minimal level of communications with North America. As an experiment, a day's worth of actual quality control data was transmitted to North America via the ATS system for evaluation by personnel there. This experiment was unsuccessful; the data bandwidth available over ATS was insufficient.

ASA provided material and technical support for some experiments for continuous transmission of differential GPS correction data to the aircraft. This support included erection of a conical-monopole antenna at Siple Dome and fabrication of data relay radio systems at McMurdo. ASA preparations for this experiment were inadequate. However the equipment was assembled and operated in tests. For survey operations it was superceded by the simpler near-vertical-incidence reflection system constructed at Siple Dome by SOAR personnel.

ASA provided a weather observer on-site at Upstream C to support SOAR. This arrangement worked out very well for SOAR and allowed significantly increased efficiencies in survey execution. Given the bad weather encountered at Siple Dome, having Upstream C as a weather alternate and refueling stop was crucial to the completion of the planned survey this year.

Flight following services were generally provided by personnel at South Pole Station since they had the most reliable HF communications with the aircraft in the survey area.

Issues to Address.

To maintain and improve the efficiency of aircraft configuration and flight operations, as well as to ensure that flight operations are conducted safely, a number of issues need to be addressed. These are listed below.

Voice and data communications links to North America continue to be important to the operation of the survey aircraft due to the highly technical nature of the facility's suite of geophysical, positioning and computing systems. Reliable voice and data communications links must be established with the SOAR facilities in North America. These links should be installed prior to the arrival of SOAR field personnel. Based on experiments conducted this year the volume of traffic supported should be increased to ten megabytes per day to allow quality control products to be evaluated by SOAR personnel and science observers in North America.

Flight following capability is critical for safe operation of the survey aircraft. This consists of a weather observer at a radio tuned to the survey aircraft frequency from one hour prior to take-off of a flight until the flight lands. The around-the-clock nature of SOAR field operations necessitates that twenty-four hour flight following be provided at the main base and all satellite bases if possible.

This season one of the SOAR personnel was evacuated from Siple Dome Camp due to medical problems. This medivac highlighted some problems in the field camp medical policies including (a) communication of serious medical problems to the responsible field camp personnel and (b) procedures for determining when to move personnel to McMurdo for further evaluation. The details of the 1997 medivac were as follows. The SOAR person suffered a chronic problem, treated by the camp Emergency Medical Technicial (EMT) for over thirty days, which eventually led to a medivac. Although the camp EMT and the McMurdo doctors were in full communication regarding this case, neither the senior SOAR personnel nor the camp manager were advised of the situation. This failure of communications resulted both in the absence of a rigorous tracking of the medical problem and absence of a plan for transporting the personnel to McMurdo for further evaluation in a non-emergency mode. The patient's condition deteriorated rapidly to the point that a medivac was required on January 4, 1997. As an LC-130 was unavailable for several hours, the fully configured survey aircraft was used to transport the patient and accompanying personnel. Although McMurdo is at the limit of the fully configured Twin Otter's range, the flight was uneventful. Marginal weather at Siple Dome prevented the return of the survey aircraft to Siple Dome for five days.

Future Targets.

To address these outstanding issues, SOAR intends to request the following:

Occupation of Siple Dome Camp as the SOAR main base with satellite operations at Downstream B and South Pole Station.

Establishment of ATS (or better) voice and data communications links at the field site prior to the arrival of SOAR field personnel with a detailed plan for upgrading to ten megabytes per day throughput to allow monitoring of QC products in North America.

Implementation of flight following capability with hourly updates from three locations during flight operations, Siple Dome, Downstream B and South Pole Station.

Maintenance of two alternate landing sites with fuel caches positioned at least seventy-five kilometers and no more than 200 km away from each base of operations. When possible the other SOAR bases can fill this role on a mutually supporting basis. New fuel caches may need to be installed.

To address the field camp medical policy problems encountered this year we propose two new approaches. First SOAR will implement a policy for SOAR personnel to communicate medical problems to the SOAR senior personnel in the field. Secondly we request that camp medical personnel inform both the camp manager and the SOAR senior personnel of developing medical problems for SOAR personnel.

III. Technical Support

This appendix covers the interactions of the facility with other organizations which provided technical support. The technical support was provided for the gravity meter and the geodetic GPS receivers.

A. Gravity Meter

Goal.

The goal of SOAR is to secure reliable access to a state-of-the-art gravity meter designed for airborne applications.

Plans and Accomplishments.

The plan this year was to obtain and operate the BGM-3 gravimeter modified for airborne use owned by the Naval Oceanographic Command (NAVOCEANO). This device was picked up from NAVOCEANO at Stennis Space Center, MS on October 28 and returned on February 28. It worked well throughout the season. Weekly reports on gravity meter status were sent to NAVOCEANO from the field.

Issues to Address and Future Targets.

Transportation of the gravity meter is somewhat difficult with its need to be powered constantly and to have an escort. This issue is addressed fully in the succeeding Cargo section.

In order to support the next field season SOAR plans to obtain the gravity meter for the period from late October 1997 to February 1998.

B. GPS Systems for Precise Positioning

GPS technology is utilized by SOAR in two different ways: as a real-time tool to allow accurate airborne navigation along a pre-determined flight path, and to precisely determine the aircraft's position for post-mission data reduction. This section addresses this latter use of GPS, as a precise geodetic positioning system.

Goal.

The goal of SOAR for precise positioning is to gain reliable access to the GPS equipment best suited for routine sub-meter position determination of the survey aircraft.

Plans and Accomplishments.

SOAR again this year utilized both Ashtech Z-12 and Turborogue GPS receivers. For reliability the two receiver types operated in parallel both in the aircraft and on the ground. Multiple receivers of each type were used to prevent data loss due to individual receiver failure.

This year's plan for GPS receivers was to borrow two Turborogues from the UNAVCO, buy one new Turborogue and buy three new Ashtech Z-12s, giving the complete suite of three of each type.

UNAVCO provided two Turborogues for facility use. Two complete systems were delivered to SOAR in August, providing time to train SOAR personnel in their operation. These systems were returned to the UNAVCO representative at McMurdo at the end of the season.

Lamont-Doherty Earth Observatory (LDEO) of Columbia University loaned four new Ashtech Z-12 receivers to SOAR for the season.

Prior to the field deployment SOAR purchased one Turborogue receiver. Because of the LDEO loan the planned purchase of Ashtech Z-12s was deferred until after the field season to allow more consideration of acquisition options.

Issues to Address.

The introduction of satellite bases of operations this year will increase the number of GPS receivers needed by two per active satellite base. To allow commonality at the satellite bases it would be best for all the satellite base receivers be Ashtech Z-12s.

Other organizations at or near the satellite bases (South Pole Station) are operating fixed GPS base stations. It may be possible to coordinate GPS operations.

The SOAR relationship with UNAVCO should be reevaluated in light of the goal for SOAR to reduce or eliminate its requirements for borrowed GPS receivers.

Future Targets.

SOAR needs seven Ashtech Z-12s to equip the aircraft, main and two satellite bases. For the upcoming season SOAR intends to purchase one and try to borrow the remainder from the SOAR host institutions.

SOAR will evaluate coordination with existing GPS operators at South Pole Station for the upcoming field season.

SOAR plans to take over custody and maintenance responsibilities of the two OPP Turborogue receivers currently in the UNAVCO pool. SOAR encourages Polar Programs to continue fostering a relationship with UNAVCO to ensure continuing excellent technical development and support.

IV. Cargo Support

This section reviews the cargo support provided to the facility by ASA. A significant quantity of cargo must be moved annually from the SOAR central office in Austin, Texas, to the field site in a timely manner. To date it has been necessary for much of this equipment to be returned to North America quickly so that data distribution activities could begin soon after the field season.

Goal.

The SOAR cargo goal is to move equipment to the field site in a manner which supports the timetable for configuring and operating the survey aircraft and associated ground support facilities.

Plan.

The facility's plan for the 1996/97 field season was to:

Have the equipment necessary to set-up the survey aircraft on-site at Siple Dome Camp before November 1996 and to have all other equipment at the field site before the arrival of the survey aircraft in early November.

Transport of the gravimeter from North America to Antarctica requires a SOAR escort. The escort is needed to ensure that continuous power is supplied to the meter and to repair any failures during transport. Transport of the gravity meter back to North America via the New York Air National Guard as undertaken in previous seasons is not timely if the field season ends in early January as was planned for 1996-97. Because of this an attempt was made to find alternate means of transportation to avoid an expensive delay in returning this device. The final plan called for commercial transport of the gravity meter and escort within North America and military transportation beyond that.

SOAR planned to reduce the volume of handcarry.

To reduce the amount of paper documents carried to and from the field SOAR planned to investigate creating and archiving many of these on electronic media.

Shipping containers were to be acquired to replace broken and damaged ones.

Accomplishments and Events.

Cargo deployment accomplishments are shown below in two tables. Table C.2 describes the amount of cargo in each of the eight SOAR 1996/97 shipments. Table C.3 describes the timing of each of these cargo shipments.

Table C.2
Cargo Summary

Shipment Number	Number of Pieces	Total Weight (lbs)	Volume (ft^3)
1 (Kilo Air shipment)	23	5729	495
2	9	2134	251
3	21	3505	380
4	14	3102	291
5	8	912	90
6	1	295	23
7	2	652	45
8	2	215	24
Total	80	16544	1599

Gravity Meter Shipping.

As it is each year, shipping the gravity meter was a high profile and resource intensive process. The "live" gravity meter sensor weighs 330 pounds including its shipping container. The complete system included three additional boxes totaling 392 pounds for a total gravity meter weight of 712 pounds.

Table C.3
Cargo Timetable

Shipment Number	Date Departed Austin, TX	Arrival Dates		
		Port Hueneme	Christchurch	McMurdo
1	23 Aug	28 Aug	30 Sep	15 Oct
2	17 Sep	19 Sep	30 Sep	15 Oct
3	24 Sep	27 Sep	14 Oct	19 Oct
4	01 Oct	03 Oct	15 Oct	21 Oct
5	08 Oct	11 Oct	21 Oct	24 Oct
6	15 Oc	16 Oct	24 Oct	28 Oct
7	25 Oct	28 Oct	05 Nov	06 Nov
8	07 Nov	08 Nov	19 Nov	20 Nov

Problems were encountered in transporting the gravity meter both to and from Antarctica this year. On the way down, all the gravity meter boxes except the "live" sensor were separated from the SOAR escort due to aircraft fuel/range limitations. These items ended up going through Australia and incurring a delay. On the way back the gravity meter was delayed at Christchurch waiting for suitable military transport across the Pacific and then encountered maintenance delays en route. The gravity meter left Siple Dome Camp on January 20 and was ready for retrograde to North America at that time. It ultimately left Christchurch on February 9. To avoid further delays the gravity meter and SOAR escort left the military airlift system at Hawaii and flew via commercial airline to Dallas on one non-stop flight arriving on February 15.

Handcarry.

In addition to the cargo denoted in the Tables C.2 and C.3, certain items were required to be hand carried from North America to Antarctica because of their late availability, critical importance or immediate need upon arrival. SOAR personnel hand carried nine pieces (938 lbs) down and eight pieces (550 lbs) back this year.

The number and weight of hand carried items this season was significantly reduced over last year through better planning and a concerted effort to discourage hand carried items.

Several time sensitive items hand carried in the past -- the gravimeter items not requiring an escort and borrowed GPS receivers -- were retrograded via commercial air instead.

Paper Reduction.

SOAR purchased a document scanner for field use. All paper documents produced in the field were scanned. The largest volume of these have been the several thousand pages of flight plans, flight logs and quality control documents. The scanned images were hand carried back with a copy of the season's data. This and other efforts to reduce the amount of paper documents generated and transported from the field paid off in reduced handcarry weight and volume. Also the electronic copies were much easier to replicate and archive.

Equipment Staged at McMurdo.

SOAR packed several large crates of equipment to be left at McMurdo over the winter. This equipment included computer monitors, bulk paper, power and coaxial cables and the big HF radio amplifier. This policy saved logistics effort in retrograde this year and will reduce cargo weight for next year.

New Shipping Containers.

One large shipping container for the radar antennas (or other oversized items) was purchased. Three smaller 16 ft^3 cases and four handcarry cases (large suitcase sized) were also purchased. Several worn out wooden boxes used as shipping containers were "retired".

Issues to Address.

To optimize resources during the next field season the following issues/targets must be addressed.

The gravity meter transportation scheme was not reliable for the 1996/97 field season. Meter components were bumped from flights. Changing transportation arrangements for the gravity meter increases the chances that the system will undergo an expensive failure or that it will become separated from its escort. Lengthy delays in gravity meter transport cause significant additional costs.

The additional equipment required by SOAR to implement satellite bases of operation will cause an increase in cargo. Further reductions in cargo weight and volume will be difficult to achieve for the next season's shipping.

Future Targets.

SOAR's cargo requirement for next year is estimated to be the same as last year plus a small (<1000 lbs) increase to accommodate equipment for two satellite bases. Handcarry amounts should stay about the same.

SOAR will work with ASA to arrange acceptable commercial transportation for the gravity meter all the way to Christchurch and back to North America from Christchurch.

Appendix D: Personnel
SOAR Annual Report
1996/97

This appendix covers the goals, plans, accomplishments, outstanding issues and future targets for SOAR personnel.

Goals.

The SOAR personnel goals are to staff the facility with a stable core of highly qualified technical people and to maintain a flexible management structure that allows the core personnel to be easily augmented during periods of peak activity.

Plan.

The personnel plan for the second year of SOAR activities focused on the following:

Administrative Activities.
With additional science clients seeking help from the facility the administrative load has been increasing. SOAR planned an increase of the science coordinator's, systems analyst's and administrative assistant's appointments.

Technical Activities.
To achieve SOAR's planned technical upgrades, extensions in the appointments of the research engineer and installation engineer were planned.

Presently, the senior systems analyst and research engineer share appointments between SOAR and UTIG science projects. Conflicts can arise especially with SOAR field preparation and data distribution. SOAR planned to evaluate changing the balance of their tasks and possibly hiring a new "core" person.

Field Activities.
Augmenting the core personnel with sufficient personnel to accommodate the field preparation schedule and to allow for high production (three flights per day) flight operations in the field.

A one month extension of the appointment of a co-director who goes to the field for SOAR was planned.

Implementing a contract for computer data products in the field. This approach was intended to reduce the inefficiencies associated with hiring temporary field personnel each year to generate those products.

Accomplishments.

Administrative.

SOAR increased the time period of the science coordinator's and systems analyst's appointments to handle the increased load assisting science clients.

Technical.

The appointments and schedules of the core research engineer and senior systems analyst were adjusted to better accommodate conflicting demands of SOAR and UTIG requirements.

The time periods of the research engineer and installation engineer were increased to deal with the new technical developments undertaken this year.

Field.

The private firm Expedition Computing Services (ECS) was contracted this year to supply computer data products in the field. Four employees of this company worked at the SOAR field camp in this capacity. This arrangement worked well and all goals in implementing this contract were achieved.

The appointment of a co-director who goes to the field for SOAR was extended to encompass the field time (one month).

To augment the core staff for the field season the following positions were temporarily filled:

- Augmented Installation Engineer - Don McNair.
- Augmented Research Engineer - Robert Trevino, an employee of NASA Johnson Space Center. Due to Johnson Space Center's interest in Antarctic operations, NASA retained Trevino on payroll, placing him with SOAR as a temporary assignment.
- Augmented Field Assistant - Vicki Langenheim, employed by the USGS, participated under the USGS subcontract to SOAR.

The core SOAR personnel this year were:

Co-director - Don Blankenship (Ph.D. Geophysics, 1989, University of Wisconsin-Madison) has 12 austral summers of field experience in Antarctica, seven as chief scientist including the Corridor Aerogeophysics of the Southern and Eastern Ross Transect Zone (CASERTZ) surveys and the three SOAR field seasons. His efforts there have concentrated on aerogeophysics and seismology.

Co-director - Robin Bell (Ph.D. Geophysics, 1989, Columbia University) has spent three austral summers in Antarctica as chief scientist for the CASERTZ surveys and two austral summers doing long-range aerogeophysics over the Weddell Sea. Her work has been in marine and airborne geophysics with an emphasis on gravity measurements.

Technical Coordinator - Tom Richter (M.S. Electrical Engineering, 1993, University of Texas at Austin) served his second field season with SOAR this year. In the past, he was a pilot and an operational test director for aircraft systems for the U.S. Navy. He has been with the University of Texas since 1991, working on a variety of electrical, electronic and software systems for research programs.

Science Coordinator - Jeff Williams (M.S. Geophysics, 1995, University of Texas at El Paso) joined SOAR shortly before its first field season. His background includes advanced studies in applied geophysics and service as a U.S. Air Force officer and test director for airborne life-support systems. The Science Coordinator's primary responsibilities include interaction with SOAR science clients and data distribution.

Research Engineer - Matt Peters (Ph.D. Electrical Engineering, 1994, The Ohio State University) joined SOAR immediately upon completion of his Ph.D. His doctoral research focus was on antennas and wave propagation for airborne applications. One of the early engineers on the CASERTZ project, he assisted in field preparations and participated in two CASERTZ field seasons. Peters has participated in all three SOAR field programs and has primary operational responsibility for geophysical systems.

Senior Systems Analyst - Scott Kempf (M.S. Computer Science, 1992, University of Wisconsin-Madison) also moved to SOAR from CASERTZ where he had spent a year programming database applications for underway geophysics. His background at the University of Wisconsin includes experience in systems architecture, programming tools and assembly language applications as well as six years as a network administrator. His primary responsibilities include software development for data acquisition and data distribution.

Systems Analyst - John Gerboc (M.S. Systems Science, 1991, State University of New York at Binghamton) joined SOAR prior to its first field season. His previous experience was in software development for vision and airborne systems. While a software engineer at IBM Federal Systems Division he participated in a number of aircraft based field projects. While with SOAR, he has participated in all three field programs with operational responsibility for data acquisition and data distribution.

Installation Engineer - Ken Griffiths (B.S. Electrical Engineering, 1968, Duke University) is a Research Engineer with the Institute for Geophysics who acts as installation engineer for SOAR. Griffiths has participated in more than ninety marine, land and airborne geophysical field programs including all three SOAR field seasons. Griffiths has both developmental and operational responsibilities for geophysical and navigational systems.

Administrative Associate - Wilbert King (B.S. Economics, 1995, University of Texas at Austin) was selected from a wide variety of candidates for this position because of his familiarity with computer oriented administration. He has substantial experience with the management of administrative databases as well as University of Texas budgeting. His responsibilities for SOAR include information management and logistics coordination.

The temporary personnel added to augment staffing for the field deployment this year were:

Installation Engineer (augmented) - Don McNair, a retired geophysical technician at the Geophysics Branch of the USGS with over twenty years of geophysical field experience, was hired temporarily to assist with field logistics and equipment setup. He participated in both previous SOAR field programs.

Field Assistant (augmented) - Vicki Langenheim (M.S. Geology, 1989, University of California at Berkeley) is a geophysicist with the USGS where she uses potential field data to solve tectonic problems. She flew with SOAR as the Control Computer Operator and operated base station instrumentation. This was her second field season with SOAR.

Research Engineer (augmented) - Robert Trevino (M.A. Public Administration, 1988, University of Houston at Clear Lake City; B.S. Aerospace Engineering, 1972, University of Texas at Austin) is an engineer with the NASA Johnson Space Center where he works on advanced extravehicular activity planning. He flew with SOAR as the Potential Fields and Navigation Systems operator and assisted with equipment setup.

The personnel who worked under the Expedition Computing Services contract to supply computer data products in the field were:

Senior Systems Analyst (augmented) - Mark Maybee (Ph.D. Computer Science, 1994, University of Colorado-Boulder). His background includes over ten years of research experience in software engineering as well as substantial systems programming experience. He has participated in all three SOAR field programs.

Senior Systems Analyst (augmented) - Dwight Melcher (B.S. Applied Mathematics and Computer Science, 1986, University of Colorado-Boulder). He has over nine years experience with UNIX, programming languages and system administration. He also participated in the 1995/96 SOAR field program.

Senior Systems Analyst (augmented) - Eric Robison has over seven years experience as a systems and network administrator. He also participated in the 1995/96 SOAR field program.

Systems Analyst (augmented) - Geoff Phelps (B.A. Geology, 1990, University of California at Berkeley). His background includes seven years with the USGS and extensive experience with GIS systems and UNIX system administration.

Issues to Address.

Data Reduction.

The staffing at SOAR to reduce raw data to transect products as tasked for this coming year does not currently exist.

Technical.

Evaluation and specification of a coherent radar for SOAR is scheduled to begin in 1997/98. Because of current engineering commitments and the scope of this project it cannot be covered by existing engineering staff.

Administrative.

In order to deal with increasing interaction and support of clients and potential clients SOAR needs to increase the level of administrative support.

Field Expedition Issues.

The issue of finding qualified personnel to supply computer data products in the field identified last year is still applicable. The ECS contract worked well. An extension of the subcontract with ECS or some alternative arrangement to obtain these products must be made.

Personnel must be available for the upcoming field season to operate the aircraft, main base at Siple Dome Camp, and two satellite bases, one at Upstream B and one at South Pole Station.

A long term plan must be implemented to manage SOAR personnel who have been required to participate in lengthy, consecutive field seasons. A rotation plan will be necessary to maintain the established levels of safety and productivity without significant staff turnover. Long field seasons are slated for the upcoming years due to the high demand for SOAR resources.

Future Targets.

To support SOAR personnel requirements and address the outstanding issues SOAR intends the following actions:

Data Reduction.

To accomplish the data reduction tasking SOAR intends to hire two full time data reduction specialists as detailed in Appendix A to this report. The persons will start a six month training period beginning in late summer 1997 to be fully prepared for the arrival of the 1997/98 data in January or February 1998.

Technical.

SOAR intends to assign the coherent radar evaluation and specification to the existing research engineer. A new engineer to assume most of his current tasking will be hired. This is consistent with the additional research engineer appointment planned but not implemented last year.

Administrative.

SOAR intends to add one month of support by an administrative assistant to the year's personnel budget.

Field Expedition.

SOAR intends to put in place a two year extension to the existing contract with Expedition Computing Services (ECS) to continue supplying QC and data archival products in the field. In addition, the statement of work for ECS is to be expanded slightly with the additional responsibility to optimize the architecture of the download and QC computer network.

The basic staff level to support survey operations in the upcoming field season is calculated at thirteen, assuming six core SOAR personnel, three augmented SOAR personnel and four ECS employees. The two SOAR directors will also be available at critical times in the field to assist with operational transitions, bringing the personnel total to fifteen. This field staffing level is sufficient to handle aircraft and base assembly and takedown as well as aircraft and base station operation. The new satellite bases will require a SOAR person at Downstream B and to avoid adding a resident to South Pole Station SOAR will investigate training one of the support staff to operate the SOAR base equipment.

To prevent the loss of personnel due to the requirement of lengthy field deployments in multiple consecutive years, SOAR will implement a personnel rotation policy. The goal is to target an eight week field season for trained SOAR personnel. An employee's first season will be considered a training period and a full season will be planned. Each subsequent consecutive season will be limited to approximately eight weeks. This plan can be realized without increased staffing levels due to enhanced efficiencies in flight operations.

Appendix E: Oversight Committee
SOAR Annual Report
1996/97

This appendix reviews the results and findings of the 1996 meeting of SOAR's Oversight Committee.

Goals.

The charter for the SOAR Oversight Committee lies in the Cooperative Agreement established between the University of Texas at Austin and the National Science Foundation, Office of Polar Programs (NSF/OPP). In it the Facility was asked to establish an external oversight committee tasked with "defining broad areas of scientific interest and keeping abreast of technological developments."

Plans.

The committee is to meet annually and is intended to represent the interests of the polar earth science, glaciology, general earth science and aerogeophysical operations communities. The facility co-directors, the NSF/OPP Program Officer and a U.S. Antarctic Program Operations Manager are all to be represented at committee meetings.

Accomplishments.

The second annual meeting of the SOAR Oversight Committee was held at the NSF headquarters in Arlington, Virginia on September 24, 1996. The members of the committee are:

- Robert Bindschadler (glaciologist), Goddard Space Flight Center, NASA.
- Terry Wilson (polar earth science), Department of Geology and Mineralogy, The Ohio State University.
- Terry McConnell (aerogeophysical operations), SCINTREX, Concord, Ontario.
- Jian Lin (earth science), Woods Hole Oceanographic Institute, Massachusetts. Jian Lin joined the SOAR oversight commmittee in 1996.

The National Science Foundation was represented by Scott Borg and Julie Palais, NSF/OPP. The SOAR co-directors, technical coordinator and science coordinator were also present. Terry Wilson was unable to attend.

The major topics discussed by the Committee were:

1. Project Selection and Timing -- Policy Direction

Committee recommendation for choosing projects for SOAR execution:

Fill up the next two years with projects based on their science merits. Schedule projects for each year based on logistics issues.

Committee recommendation for multiple bases in a year:

It is acceptable to use multiple bases in a year but keep the main quality control functions in one location. Use secondary bases with basic QC capabilities and/or fuel to maximize flexibility in areal coverage.

2. Instrumentation -- Technical Direction

Technical improvements in work for 1996/97 season:

a) New radar digitizer.
b) Differential GPS for aircraft guidance.
c) Improved inflight QC.
d) Contractor supplied software QC support.

Future Improvements:

a) Coherent radar (as recommended by the oversight committee last year).
b) Continuing development of inflight QC.
c) Magnetometer.

Looking into the future, there may be a need for SOAR to move to higher precision magnetometers for studying geological structure. The two options proposed were a cesium optically pumped magnetometer or a three component magnetometer to acquire vector rather than just scalar magnetic field strength measurements.

Proposal-Driven Technical Developments:

One of the current proposals for the use of the SOAR platform requires testing and calibration of some equipment in the field, followed by analysis of the test data. The Committee recommendation for this situation is to:

a) Look for existing ground and air data which establishes the calibration.
b) Do the calibration flights during the 1996/97 season, the data analysis over the summer and fly the actual survey the next season.
c) As a general policy do not do data reduction in the field.

3. <u>Data Reduction Policy</u>

All proposals currently submitted for future use of the SOAR facility request either Transect Products or Grid/Map Products. Right now SOAR can only provide raw data. Options to generate reduced data products:

a) SOAR subcontracts to get the work done.
b) SOAR obtains the software and hires the technical expertise to reduce the data itself.

The Committee recommended that the prime data product be the Transect Data Product. Grid/Map data is a standard item which can be generated easily once the Transect Product is available. The Committee recommended timetable is:

a) Reduced 1997/98 data available to the PIs 6-9 months after collection.
b) Reduced 1998/99 data available 6 months after collection.

Other Committee recommendations for Data Reduction Policy:

a) NSF needs to review the funding issue to hire a separate data processing staff to accomplish data reduction while collection is still going on.
b) Deliver finalized data streams as they become available.
c) Long-term Data Archiving. Currently there is no external agency (e.g. NGDC or NOAA) which archives SOAR data. The Committee recommeded that the SOAR directors find an agency to archive the SOAR data and give a recommendation to NSF.

4. Flight Safety

In light of the recent accidents in world wide airborne geophysics operations the Committee recommended:

a) SOAR establish a Safety Procedure Manual.
b) SOAR establish and practice safe operating procedures.

Issues to Address and Future Targets.

Fifth Oversight Committee Member.
Preliminary contacts have been made with Tim Ahern of the University of Washington. Ahern is affilliated with The Incorporated Research Institutions for Seismology (IRIS) and possesses expertise in data management issues.

Next Meeting.
Funds need to be allocated for the 1997 meeting of the oversight committee, not scheduled as yet.

Appendix F: Finances
SOAR Annual Report
1996/97

This appendix covers the plans, accomplishments and future targets for SOAR finances.

Goal.

The financial goal of SOAR is to support the core staff and physical facility necessary to prepare, configure and operate a geophysical aircraft in Antarctica. Starting with SOAR Year 4 these activities will include reduction of raw data to a transect product. These objectives are to be accomplished for the lowest cost consistent with the data volume and data quality specified in the facility's experimental tasking.

Plans and Accomplishments:

The plans and accomplishments for the third year of SOAR operations are outlined in Attachment F.1 which presents the initial budget estimates and their reconciliation as of the end of April 1997. The expenditures differ from the original estimates for the following reasons -- 1) a second Research Engineer was budgeted but that role was covered by a person on temporary assignment from NASA for the Antarctic field expedition, 2) the purchases of three GPS receivers and three digital signal averager cards were deferred pending final technical decisions, 3) various lesser economies in the Other Direct Costs items summed to a significant cost savings.

Issues to Address and Future Targets:

The new issues for Year 4 which significantly influence the budget are:

a) Resources required to support the increase in data management efforts caused by the new data reduction tasking.

b) The implementation of satellite base stations for the upcoming field expedition.

c) Replacement of the old aircraft magnetometers.

d) Personnel resources allocated to studying available coherent radar technologies and defining the new system for the SOAR aircraft.

Other budget targets are similar to those for Year 3 however slight adjustments have been applied to several other Direct Costs to better reflect past expenditures.

Attachment F.1
Year 3 Budget Reconciliation - Institute for Geophysics
05/01/96 - 04/30/97

		Months	Budgeted	Projected Expenditures
A.	Senior Personnel			
	1. D.D. Blankenship	5.0		
B.	Other Personnel			
	2. Technical Coordinator	9.0		
	Science Coordinator	12.0		
	Senior Research Engineer/ Installation Engineer	5.0		
	Research Engineer	12.0		
	Senior Systems Analyst	9.0		
	Systems Analyst	12.0		
	Augmented Installation Engineer	2.0		
	5. Administrative Assistant	8.0		
	Total Salaries		261,809	227,906
C.	Fringe Benefits		67,526	52,588
	Total Salaries & Fringe Benefits		329,335	280,494
D.	Permanent Equipment			
	1. (3) Geodetic GPS Receivers -- Ashtech		57,000	
	2. (1) Geodetic GPS Receiver -- Turborogue		22,500	
	3. DSU Upgrade Hardware		35,000	
	4. Radar Upgrade Hardware -- D/A Boards		29,700	
	5. Shipping Containers		6,000	
	6. Workstation (RAV Network)		8,400	
	7. Tape Drive and Printer (RAV Network)		2,800	
	Total Permanent Equipment		161,400	100,731
E.	Travel			
	1. Domestic			
	4 R/T Austin-Golden CO (Denver)		1,200	
	8 Days Per Diem		560	
	2 R/T Austin-Calgary		2,200	
	6 Days Per Diem		840	
	4 R/T Austin-Bay St. Louis		1,600	
	8 Days Per Diem		960	
	4 R/T (various)-Austin oversight committee meeting		2,400	
	8 Days Per Diem		960	
	2 R/T Austin-Washington D.C.		1,000	
	4 Days Per Diem		560	
	2. Foreign			
	48 Days Per Diem, Christchurch		5,760	
	Total Travel		18,040	17,359
G.	Other Direct Costs			
	1. Materials and Supplies:			
	Field Supplies		4,250	
	Electronics		10,800	
	5. Subcontracts			
	USGS		33,700	
	LDEO		87,473	
	Expedition Computing Services		96,400	
	6. Other:			
	Computer Leasing		9,000	
	Shipping		19,100	
	Insurance		16,900	
	8 Physicals		5,200	
	Repair/Refurbishment		46,100	
	Copying		850	
	Communications		3,400	
	Lease Payments		94,400	
	Total Other Direct Costs		427,573	376,228
H.	**Total Direct Costs**		936,348	774,812
I.	**Indirect Costs**		107,355	86,905
	22% Excluding Equipment, Lease Payments and Subcontracts (beyond the first $25K)			
J.	**Total Costs**		1,043,703	861,717

Attachment F.1
Year 3 Budget Reconciliation - Lamont-Doherty Earth Observatory
05/01/96 - 04/30/97

		Months	Budgeted	Projected Expenditures
A.	Senior Personnel			
	1. R.E. Bell, Associate Research Scientist	4.0		
B.	Other Personnel			
	5. Administrative Assistant	3.0		
	Total Salaries		29,311	20,860
C.	Fringe Benefits		9,819	6,988
	Total Salaries & Fringe Benefits		39,130	27,848
D.	Permanent Equipment			
	1. Macintosh Powerbook		2,500	3,402
	Total Permanent Equipment		2,500	3,402
E.	Travel			
	1. Domestic			
	2 R/T New York - Golden CO (Denver)		2,720	
	10 Days Per Diem		1150	
	4 R/T New York - Austin		4,352	
	21 Days Per Diem		2121	
	Misc. Ground Transportation		150	
	Total Travel		10,493	8,939
G.	Other Direct Costs			
	1. Materials and Supplies		350	
	2. Computer Services		2700	
	6. Other:			
	Shipping		550	
	Copying and Communications		3,250	
	Total Other Direct Costs		6,850	16,007
H.	**Total Direct Costs**		58,973	56,196
I.	**Indirect Costs**		28,500	26,954
	53% excluding equipment and computer services			
J.	**Total Costs**		87,473	83,150

Attachment F.1
Year 3 Budget Reconciliation - USGS/Geophysics Branch
05/01/96 - 04/30/97

NO DATA AVAILABLE

Attachment F.1
Year 3 Budget Reconciliation - Expedition Computing Services
05/01/96 - 04/30/97

		Months	Budgeted	Projected Expenditures
A.	Senior Personnel			
	1. Mark Maybee	2.0		
	Dwight Melcher	2.5		
	Eric Robison	2.5		
B.	Other Personnel			
	5. Systems Analyst	3.0		
	Total Salaries		53,892	57,166
C.	Fringe Benefits		17,784	18,048
	Total Salaries & Fringe Benefits		71,676	75,214
E.	Travel			
	1. Domestic			
	4 R/T Golden CO (Denver) - Austin		2,000	
	42 Days Per Diem		5,040	
	2. Foreign			
	28 Days Per Diem - Christchurch NZ		3,360	
	Total Travel		10,400	8,700
G.	Other Direct Costs			
	1. Materials and Supplies		1000	
	6. Other:			
	Shipping		500	
	Communications		1,500	
	Physicals		1,400	
	Lease/rent/storage		7,000	
	Postage		50	
	Utilities		840	
	Books/tech literature		800	
	Misc		500	
	Total Other Direct Costs		13,590	11,686
H.	**Total Direct Costs**		95,666	95,600
I.	**Indirect Costs**		0	0
J.	**Total Costs**		95,666	95,600

Attachment F.2
Year 4 Budget Estimate - Institute for Geophysics
05/01/97 - 04/30/98

		Months	Budgeted
A.	Senior Personnel		
	1. D.D. Blankenship	5.0	
B.	Other Personnel		
	2. Technical Coordinator	9.0	
	Science Coordinator	12.0	
	Senior Research Engineer/ Installation Engineer	5.0	
	Research Engineer	12.0	
	Research Engineer for Coherent Radar	6.0	
	Senior Systems Analyst	9.0	
	Systems Analyst	12.0	
	Research Engineer (Field Augment)	5.0	
	Installation Engineer (Field Augment)	2.0	
	Data Reduction Specialist (Data Reduction)	9.0	
	Data Processor (Data Reduction)	4.0	
	Senior Systems Analyst (Data Reduction)	2.0	
	5. Administrative Assistant	9.0	
	Total Salaries		364,293
C.	Fringe Benefits		89,782
	Total Salaries & Fringe Benefits		454,075
D.	Permanent Equipment		
	1. (1) Geodetic GPS Receiver -- Ashtech		18,000
	2. (2) Equipment for Portable Base Stations		20,000
	3. (2) Cs Airborne Magnetometers		50,000
	4. Magnetometer Winch (backup)		7,000
	5. (2) DAI Systems (replace DAI 1200)		10,000
	6. Spares for Precision A/C Navigation		15,000
	7. Field QC Workstation (spare)		14,000
	8. GPS Download Computer		3,000
	9. Field Weather Imaging System		4,000
	10. Workstation (Data Reduction)		12,500
	11. Computer Tape Drive (Data Reduction)		4,500
	12. (2) Computer Disks (Data Reduction)		5,000
	13. Printer (Data Reduction)		2,500
	Total Permanent Equipment		165,500
E.	Travel		
	1. Domestic		
	2 R/T Austin-Calgary		2,200
	6 Days Per Diem		840
	4 R/T Austin-Bay St. Louis		1,600
	8 Days Per Diem		960
	4 R/T (various)-Austin oversight committee meeting		2,400
	8 Days Per Diem		960
	2 R/T Austin-Washington D.C.		1,000
	4 Days Per Diem		560
	1 R/T Austin-Boston		600
	5 Days Per Diem		600
	1 R/T Austin-Denver		600
	5 Days Per Diem		600
	2 R/T Austin-Palisades NY (Data Reduction)		1,200
	10 Days Per Diem		1,200
	2. Foreign		
	1 R/T Austin- Cambridge, UK		1200
	7 Days Per Diem		1120
	54 Days Per Diem, Christchurch		6,480
	Total Travel		24,120
G.	Other Direct Costs		
	1. Materials and Supplies:		
	Lab Supplies		4,000
	Field Supplies		15,000
	Electronics		10,000
	Supplies for Data Reduction		900
	4. Computer Services (Data Reduction)		2,000
	5. Subcontracts		
	USGS		33,700
	LDEO		190,451
	Expedition Computing Services		90,000

	6. Other:	
	Computer Leasing	2,500
	Shipping	12,800
	Insurance	10,000
	8 Physicals	5,800
	Repair/Refurbishment	36,000
	Copying	800
	Communications	3,400
	Copying and Comms (Data Reduction)	500
	Lease Payments	94,400
	Total Other Direct Costs	512,251
H.	**Total Direct Costs**	1,155,946
I.	**Indirect Costs**	128,017
	22% Excluding Equipment, Subcontracts and Lease Payments	
J.	**Total Costs**	1,283,963

Attachment F.2
Year 4 Budget Estimate - Lamont-Doherty Earth Observatory
05/01/97 - 04/30/98

		Months	Budgeted
A.	Senior Personnel		
	1. R.E. Bell, Associate Research Scientist	5.0	
B.	Other Personnel		
	2. Potential Fields Technician (Data Reduction)	9.0	
	Processing Technician (Data Reduction)	2.0	
	5. Administrative Assistant	3.0	
	Total Salaries		66,000
C.	Fringe Benefits		18,744
	Total Salaries & Fringe Benefits		84,744
D.	Permanent Equipment		
	1. Sun Ultra Workstation (Data Reduction)		19,000
	2. 9 GB Computer Disk (Data Reduction)		3,000
	3. DLT Tape Drive (Data Reduction)		3,000
	Total Permanent Equipment		25,000
E.	Travel		
	1. Domestic		
	2 R/T New York - Golden CO (Denver)		3,064
	10 Days Per Diem		1,150
	4 R/T New York - Austin		5,464
	21 Days Per Diem		2,121
	Misc. Ground Transportation		150
	1 R/T New York - Denver CO (Data Reduction)		1,314
	5 Days per Diem		575
	Total Travel		13,838
G.	Other Direct Costs		
	1. Materials and Supplies		350
	Materials and Supplies for Data Reduction		450
	2. Computer Services		2700
	Computer Services for Data Reduction		4,500
	6. Other:		
	Shipping		550
	Copying and Communications		3,250
	Copying and Comms for Data Reduction		250
	Total Other Direct Costs		12,050
H.	**Total Direct Costs**		135,632
I.	**Indirect Costs**		54,819
	53% excluding equipment and computer services		
J.	**Total Costs**		190,451

Attachment F.2
Year 4 Budget Estimate - USGS/Geophysics Branch
05/01/97 - 04/30/98

		Months	Budgeted	Projected Expenditures
A.	Senior Personnel			
	1. C. A. Finn		N/C	
B.	Other Personnel			
	2. Technician	1.5		
	Field Assistant	4.0		
	Total Salaries		19,601	
C.	Fringe Benefits		N/C	
	Total Salaries & Fringe Benefits		19,601	
D.	Permanent Equipment		0	
	Total Permanent Equipment		0	
E.	Travel			
	1. Domestic			
	2 R/T CO - Austin TX		1,500	
	2. Foreign			
	13 Days Per Diem, Christchurch		1,050	
	Total Travel		2,550	
G.	Other Direct Costs			
	1. Materials and Supplies			
	Supplies		2,000	
	6. Other:			
	Shipping		1,500	
	Physical Exam		1,200	
	Repair/Refurbishment		5,600	
	Total Other Direct Costs		10,300	
H.	**Total Direct Costs**		32,451	
I.	**Indirect Costs**		N/C	
J.	**Total Costs**		32,451	

Attachment F.2
Year 4 Budget Estimate - Expedition Computing Services
05/01/97 - 04/30/98

		Months	Budgeted
A.	Senior Personnel		
	1. Mark Maybee	2.0	
	Dwight Melcher	2.5	
	Eric Robison	2.5	
B.	Other Personnel		
	5. Systems Analyst	3.0	
	Total Salaries		50,892
C.	Fringe Benefits		16,784
	Total Salaries & Fringe Benefits		67,676
E.	Travel		
	1. Domestic		
	4 R/T Golden CO (Denver) - Austin		2,000
	42 Days Per Diem		5,040
	2. Foreign		
	28 Days Per Diem - Christchurch NZ		3,360
	Total Travel		10,400
G.	Other Direct Costs		
	1. Materials and Supplies		750
	6. Other:		
	Shipping		500
	Communications		1,000
	Physicals		1,400
	Lease/rent/storage		7,000
	Postage		50
	Utilities		840
	Books/tech literature		134
	Misc		250
	Total Other Direct Costs		11,924
H.	**Total Direct Costs**		90,000
I.	**Indirect Costs**		0
J.	**Total Costs**		90,000

Attachment F.3
Total Expenditures- Institute for Geophysics
08/01/94 - 04/30/97

		Budgeted	Projected Expenditures
A.	Senior Personnel		
B.	Other Personnel		
	Total Salaries	695,349	682,608
C.	Fringe Benefits	190,598	148,244
	Total Salaries & Fringe Benefits	885,947	830,852
D.	Permanent Equipment	350,200	259,926
E.	Travel	56,158	54,189
G.	Other Direct Costs		
	1. Materials and Supplies:	34,142	
	4. Computer Servuces	33,100	
	5. Subcontracts		
	USGS	96,521	96,521
	LDEO	274,541	270,218
	Expedition Computing Services	96,400	95,600
	6. Other:	500,891	
	Total Other Direct Costs	1,035,595	1,009,312
H.	**Total Direct Costs**	2,327,900	2,154,279
I.	**Indirect Costs**	296,878	276,544
	22% Excluding Equipment, Office Lease, and Subcontracts (except first $25,000)		
J.	**Total Costs**	2,624,778	2,430,823

Attachment F.3
Total Expenditures - Lamont-Doherty Earth Observatory
08/01/94 - 04/30/97

Attachment F.3
Total Expenditures - Lamont-Doherty Earth Observatory
08/01/94 - 04/30/97

		Budgeted	Projected Expenditures
A.	Senior Personnel		
B.	Other Personnel		
	Total Salaries	91,704	77,223
C.	Fringe Benefits	30,719	25,869
	Total Salaries & Fringe Benefits	122,423	103,092
D.	Permanent Equipment	9,282	9,611
E.	Travel	30,493	20,483
G.	Other Direct Costs	23,125	30,901
H.	**Total Direct Costs**	185,323	164,087
I.	**Indirect Costs**	89,219	79,520
J.	**Total Costs**	274,542	243,607

Total Expenditures - USGS/Geophysics Branch
08/01/94 - 04/30/97

INSUFFICIENT DATA AVAILABLE

Appendix G: Cooperative Agreement
SOAR Annual Report
1996/97

This appendix contains the five-year Cooperative Agreement between the National Science Foundation Office of Polar Programs and the University of Texas at Austin creating the Support Office for Aerogeophysical Research.

COOPERATIVE AGREEMENT NO. OPP-9319379

PARTIES:	**National Science Foundation** **and** **The University of Texas at Austin**
TITLE:	**Support Office for Aerogeophysical Research (SOAR)**
AMOUNT:	**$3,734,824**
EFFECTIVE DATE:	**August 1, 1994**
EXPIRATION DATE:	**July 31, 1999**
AUTHORITY:	This agreement is awarded under the authority of the National Science Foundation Act (42 U.S.C. 1861 et seq.) and the Federal Grant and Cooperative Agreement Act (31 U.S.C. 6301 et seq.)

This Cooperative Agreement is entered into between the United States of America, hereinafter called the "Government," represented by the National Science Foundation, hereinafter called the "Foundation" or "NSF," and The University of Texas at Austin, hereinafter called the "Awardee".

NSF Program Official:

Scott G. Borg
Office of Polar Programs
Telephone (703) 306-1033
Electronic mail: sborg@nsf.gov

NSF Grant and Agreement Official:

Pamela A. Hawkins
Division of Grants and Agreements
Telephone (703) 306-1213
Electronic mail: pahawkin@nsf.gov

TABLE OF CONTENTS TO

COOPERATIVE AGREEMENT OPP-9319379

I. Special Conditions

I. SPECIAL CONDITIONS

Article 1. Statement of Purpose and General Responsibilities

A. The Support Office for Aerogeophysical Research (SOAR), hereinafter called the "Facility," is a research facility for aerogeophysical work in Antarctica. The goal of the Facility is to develop, maintain and operate a suite of geophysical systems aboard a Twin Otter Aircraft in support of research in Antarctica for five years. The Facility has the capability of collecting and reducing ice penetrating radar, laser altimetry, magnetics and gravity data sets in addition to GPS navigation information. The Facility data product will be a well organized data set under a spatially based hierarchy described in Attachment I. Data is to be made available to the general research community according to NSF policies (see Article 2.D.4 and Article 11.B.(1) (b).

B. The Facility will be housed at the Institute for Geophysics at the University of Texas at Austin.

C. The Awardee will manage joint aerogeophysical projects under the terms and conditions of this Cooperative Agreement and an Annual Program Plan in accordance with the awardee's proposal dated July 12, 1993, revised budget dated July 7, 1994 and revised cover page dated August 22, 1994 An Annual Program Plan is to be developed in consultation with the NSF Program Official in accordance with Article 2.

D. The National Science Foundation through its Polar Earth Sciences Program will provide general project oversight, monitoring, coordination and evaluation to help assure appropriate project performance and administration.

Article 2. Scope of Work and Specific Responsibilities of Awardee

A. The Awardee will ensure that the Office of Polar Programs' scientific and other programmatic needs are effectively integrated with NSF needs as well as the needs of the national and, where appropriate, the international scientific community. All work shall be performed in accordance with this Agreement and an Annual Program Plan.

B. The Awardee shall be responsible for the activities and projects agreed upon in the Annual Program Plan. The Awardee shall establish the facilities, organization, and staffing, as well as perform the supervisory functions of scheduling, planning, budgeting, resource allocation, fiscal control, contracting, and administration necessary to fulfill the requirements of the program delineated in this Agreement and in the Annual Program Plan.

C. The Awardee shall establish the means whereby it will control the business functions of the Facility and its tasks such as, but not limited to: schedule and budget development; fiscal control, reporting, accountability, and strategic planning; and selection and subcontracting for the Facility.

D. The Facility will be used to support the Office of Polar Program sponsored aerogeophysical research in Antarctica. The projects to be supported involve the need for high quality, integrated, geographically based ice thickness, surface elevation, magnetics and gravity data sets from continental Antarctica. The following elements are integral components of the overall Awardee responsibilities:

(1) **Facility Capability**: The basic Facility will provide approximately 55 survey flights per year operating from a single base camp over approximately a 3.5 month field season. The Facility will collect ice penetrating radar, laser altimetry, magnetics and gravity data sets in addition to GPS navigation information. The personnel required to maintain this effort will be 5 facility personnel supported approximately 9 months per year augmented by temporary personnel. The Facility will include the flexibility to expand the number f lights and bases of operations with appropriately increased funding levels. As the number of science groups supported by the Facility expands, increased management expenses will also be budgeted. The Facility staff will operate the platform exclusively during this initial period of five years.

(2) **Facility Management**: The operating structure of the facility will be a Management Team consisting of two co-directors, a technical coordinator and a scientific coordinator. The co-directors are responsible for scientific guidance and technical direction of the facility. The technical coordinator will be responsible for day-to-day management of the facility and will serve as the point of contact for NSF/Operations, U.S. Antarctic Program contractors, facility contractors and sub-contractors. The scientific coordinator will be responsible for evaluating and maintaining data quality and will serve as the point of contact for collaborating investigators.

(3) **Community Interaction**: Optimum use of this community facility requires that survey design and other planning be accomplished prior to funding and scheduling of any work. During the pre-proposal phase, the Facility will be responsible for ascertaining its capabilities and limitations with respect to the proposed work, including, but not limited to, data accuracy and resolution, the design of field experiments and data management considerations. This interaction should begin no later than 60 days prior to proposal submission. The pre-proposal interaction will ensure that the investigator's specific goals can be met, that the proposed project is technically feasible, and that the project could be accommodated with uncommitted facility time. The Awardee will maintain an ongoing dialogue with NSF to allow adequate planning of future work. After notification by NSF of science project funding, the Awardee, NSF and investigators will develop plans for budgeting and project implementation. Scheduling of the aircraft will be the responsibility of the Facility Management Team in consultation with NSF. The collaborating investigator and other users of the facility may provide a representative on site during data acquisition but this representative will not be used to supplement the technical personnel either abroad the aircraft or in a ground support role. The facility personnel will be solely responsible for field operations.

(4) **Data Products and Data Policy**: The Facility product will be a well organized data set of contiguous transacts under a spatially based hierarchy (see Attachment I). Following the field season the data requested in each proposal will be gathered into its spatial hierarchy and sent by the Awardee to the collaborating investigator; this task will be completed within six months following the end of data acquisition. Each investigator may process this data to meet his/her specific objectives. The facility will also collaborate with users who do not wish to reduce their own data. The budgets for this reduction including staffing, computer resources and any associated software development will be negotiated directly with NSF. Approximately two years after acquisition of a geographically contiguous data set is completed for a science project, the data will be available for release to the general community contingent on the approval of the NSF Program Official.

(5) **Scientific Oversight**: The Facility will establish an external oversight committee tasked with defining broad areas of scientific interest and keeping abreast of technological developments. The external oversight committee, representing both the earth science and glaciology communities, will meet at least once annually and may visit the Facility annually. This committee will consist of four members; one representing the polar earth science community, one representing the polar glaciology community, one member with technical expertise in aerogeophysical operations, and one member from the general earth science community. The Facility Co-Directors will be present at all oversight committee meetings. NSF will be represented at oversight committee meetings by the NSF Program Officer, or a designated representative, and an NSF Operations Manager from the U.S. Antarctic Program. The Awardee will negotiate costs to support the activities of the oversight committee directly with the Office of Polar Programs.

(6) **Technical Development**: The Facility will pursue appropriate technical development to enhance its ability to accomplish its scientific goals. Development of capabilities beyond those required to accomplish these goals will be considered directly by NSF in consultation with the Facility Management Team and oversight committee.

(7) **Facility Administration**: The Awardee will identify points of contact to ensure close communication between the Awardee, the NSF Program Official and the NSF Grants and Agreements Official. These points of contact will be the Director of the Office of Sponsored Projects, the Office of Accounting and the Assistant to the Director of the Institute for Geophysics. Their particular responsibilities will include implementation and monitoring of Articles 8, 13 and 15 outlined below. The Awardee will also be responsible for providing a centralized location with proximal laboratories and office space of sufficient size and stability to allow facility personnel both to accomplish the tasks outlined in this article and to interact effectively with collaborators, subcontractors and other Facility visitors. The Awardee will maintain its commitment to the matching salary support outlined in the budget justification of the attached budget estimates.

Article 3. Period of Performance

This Agreement shall be effective for 60 months -- from August 1, 1994 through July 31, 1999.

Article 4. Contractual Arrangement

The Foundation authorizes the Awardee to enter into the proposed contractual arrangements with Lamont-Doherty Earth Observatory and the U.S. Geological Survey, and to fund such arrangements with agreement funds up to the amount indicated in the approved budget. Such contractual arrangements should contain appropriate provisions consistent with the applicable agreement general terms and conditions and any special conditions included in this Agreement.

Article 5. Antarctic Clause

Neither Article 5, Expenditures for Related Projects," of GC-1 nor Article 3, "Programs of Related Projects," of FDP-II may be applied to agreements from NSF's Office of Polar Programs relating to the U.S. Antarctic Program.

This agreement is subject to the Antarctic Conservation Act, 16 U.S.C. 2401 ("ACA"). Unless authorized by regulation or permit, violation of the ACA may result in civil or criminal fines up to $10,000, imprisonment for up to one year, and where appropriate, administrative sanctions up to and including debarment. Please refer to the USAP Personnel Manual for general guidance.

Article 6. Allotment of Funds

A. The total estimated cost of this Agreement from its effective date through expiration is $3,734,824.

B. For purposes of payment of cost, pursuant to the terms outlined in Article 6, the total amount currently allotted by the Government to this Agreement is $666,075. This allotment covers the initial 9-month period of performance through April 30, 1995.

Article 7. Funding Schedule and Review

A. Contingent on the availability of funds, and the acceptance of the Annual Progress Report and Annual Program Plan, NSF expects to provide funding at the following approximate levels:

Fiscal Year	Approximate Funding Level	Period of Performance
1995	$785,895	12 months
1996	$742,886	12 months
1997	$755,820	12 months
1998	$784,148	15 months

B. Under normal circumstances, data organization and management activities continue after data acquisition and are performed concurrently with planning and preparation for the next field season. In light of this, and because of the schedule in year one, an additional three months has been added to the period of performance of the final fiscal year. This will allow completion of the required organization, management and distribution of data from the final field season.

C. The actual level of continued NSF support for years 2 through 5 will be negotiated annually with the Awardee and will depend upon an annual review of progress, which may include a site visit, and the availability of funds. Continuation is dependent on NSF decisions to fund peer reviewed science proposals requiring the Facility. Should NSF decide to terminate the Facility, NSF and the Awardee will negotiate support to complete all projects in progress at that time. In the event that the anticipated level of NSF support cannot be awarded because of budgetary constraints, NSF and the Awardee will negotiate a change in the scope of Facility activities. The Facility will be reviewed after the third year of this agreement (after completion of the third field season) as described in this Article 7.D below. The review will determine if the Awardee is meeting the stated goals and objectives in order to determine if an aerogeophysical facility should be continued beyond the five year period under this Agreement.

D. A formal review of the Facility will be conducted prior to April 30, 1997. The purpose is to determine if the Facility is meeting the stated goals and objectives of this Agreement in order for NSF to determine if an aerogeophysical capability should be continued beyond the five year term of this Agreement. If this capability is to continue, this review will also be used by NSF to determine how continued work should be competed. The review is to be scheduled as not to jeopardize field operations to acquire data. The review process can include observations of NSF or reviewers from any time during the performance prior to the formal review. The review panel will be selected by NSF. The Awardee will negotiate costs to support the activities of the review panel directly with the Office of Polar Programs.

Article 8. Limitation of Funds

NSF shall not be obligated to reimburse the Awardee for costs incurred in excess of the amount currently allotted to the Agreement. The Awardee shall not be obligated to continue performance under this Agreement or incur costs in excess of said amounts unless and until the NSF Grants and Agreements Officer notifies the Awardee in writing that the amount allotted to the Agreement has been increased and specifies in such notice a revised allotment which constitutes the amount allotted for performance under this Agreement.

Article 9. Indirect Costs

The amount granted includes an indirect cost allowance at the following rate: 22% off campus rate. This modified total direct costs consists of all salaries and wages, fringe benefits, materials and supplies, services, travel and subagreements and subcontracts up to $25,000 of each subagreement or subcontracts. Equipment, capital expenditures, charges for patient care and tuition remission, rental costs, scholarships, and fellowships as well as the portion of each subagreement and subcontract in excess of $25,000 shall be excluded from the modified total direct costs.

Article 10. NSF Responsibilities

A. NSF involvement must be consistent with the general scope of work as set forth in this Agreement.

B. Performance under this Cooperative Agreement shall be subject to the general oversight and monitoring of the NSF Program Official cited on the Agreement's cover page. This NSF involvement may include, but is not limited to, the following:

1. provide advice, especially with regard to integration and coordination with NSF's Office of Polar Program activities, including:

   (a) negotiate support for science project interaction with the Facility, including definition of annual tasking and deliverables;
   (b) negotiate for twin otter support and other resources required to implement field work in Antarctica under the Annual Program Plan;
   (c) enforce and support the policy for release of data to the general research community. This policy is that approximately two years after acquisition of a geographically contiguous data set is completed for a science project, the data will be available for release to the general community. The NSF Program Official will be responsible for determining the date of completion of data acquisition for specific projects and for approving the release of data.

C. The NSF Program Official does not have the authority to and may not:

(1) request additional work outside the general scope of the Agreement;

(2) issue instructions which constitute a change as defined in Article 8 of GC-1;

(3) cause an increase or decrease in the estimated cost or time required for performance under the Agreement; or

(4) change the expressed terms and conditions of the Agreement.

D. If, in the opinion of the Awardee, any instructions or requests issued by the NSF Program Official are within one of the categories as defined in 10.C (1) through (4) above, the Awardee shall not proceed, but shall notify the NSF Grants and Agreements Officer and request, if appropriate, modification of the Agreement in accordance with Article 38, "Changes -- Limitation of Funds," of the attached Cooperative Agreement General Conditions.

E. Unless stated otherwise, all NSF approvals, authorizations, notifications and instructions required pursuant to the terms of this Cooperative Agreement must be set forth in writing by the NSF Grants and Agreements Officer.

Article 11. Awardee Reporting Requirements

A. The Awardee shall provide the NSF Program Official with annual program report detailing the prior year's effort by March 1st of each year (normally five (5) copies will be sent). This will also serve as the Awardee's request for continued support. The documentation will usually include, but is not necessary limited to the following:

(1) summary of accomplishments, future plans, and discussion of major change in direction/pace.

(2) a financial report containing the following information:

(a) a budget explanation by major project and major function for the current fiscal year and the preceding fiscal year;

(b) 4-column table (use Form 1030 budget categories) containing actual expenditures, project estimates to end of the current fiscal year, and total expenditures (actual plus projected costs). This information should also be supplied for subcontracts;

(c) a statement of funds estimated to remain unobligated at the end of the current award year;

(d) a proposed program plan in accordance with this agreement and a proposed budget for the next award year in accordance with NSF Form 1030.

B. The Awardees' staff will meet, as necessary, with NSF staff to review the relevant operations of the Facility and to exchange views, ideas, and information concerning the Facility and the Polar Earth Sciences Program.

C. The reports and plans shall be sent in the specified number of copies to the following destination:

No. of Copies	Addressee
5	National Science Foundation Office of Polar Programs, Room 755 Polar Earth Sciences Program Attn.: NSF Program Official

Article 12. Acknowledgment of NSF Support and Reports from Users

In accordance with Article 20, "Publication" of the GC-1 Grant General Conditions, appropriate acknowledgment of NSF's support should be included in reports or publication based on work performed under this Agreement.

Article 13. Key Personnel

The Facility will be under the direction of a Management Team. The following individuals are considered to be essential to the work being performed. Any change in these individuals, or any significant change in the level of effort of the individuals, under this Agreement shall require the prior written approval of the NSF Grants and Agreements Officer.

Personnel	Title	Level of Effort
Donald D. Blankenship	Scientific Director	4 months/year
Robin E. Bell	Scientific Director	4 months/year
Keith A. Najmulski	Technical Coordinator	9 months/year
TBD	Scientific Coordinator	9 months/year

Article 14. Prior Approval and Notification Requirements

In addition to the prior approval requirements as set forth in Article 2 of the GC-1 General Conditions, prior written approval by the NSF Program Official is required for equipment purchases over $15,000, which were not identified in the approved budget, and the reprogramming of funds over $30,000.

Article 15. Permanent Equipment

Title to all equipment purchased and/or fabricated with Government funds under this Agreement shall passed directly to the Government from the vendor. Within 30 days from the date of delivery by the vendor, the Awardee shall furnish the Foundation Property Management Officer with a full description of the equipment, including model and serial number, acquisition cost (including transportation charges), and the date of acquisition. The Awardee shall be responsible for property control over Government equipment until such time as it is delivered to an agent of the Foundation. Upon expiration of the Agreement, disposition of the equipment will be determined by the Foundation in consultation with the Awardee.

Article 16. Order of Precedence

Any inconsistency in this Cooperative Agreement shall be resolved by giving precedence in the following order: (a) the Special Conditions; and (b) the General Conditions.

II. General Conditions

The following General Conditions attached hereto shall apply to this Cooperative Agreement and are incorporated herein:

1. **Grant General Conditions**, GC-1 (5/94)

2. **Cooperative Agreement General Conditions**, NSF CA-1 (5/94), which is amended as follows:

   Delete Article 41, "GC-1 Deletions" in its entirety and substitute the following in lieu thereof.

41. GC-1 Deletions

The following articles in GC-1, Grant General Conditions, are not applicable to this Cooperative Agreement:

4. No-Cost Extensions
5. Expenditures for Related Projects
33. Resolution of Conflicting Conditions (GC-1)
40. Resolution of Conflicting Conditions (CA-1)

IN WITNESS WHEREOF, the parties have executed Cooperative Agreement No. OPP-9319379 "Support Office for Aerogeophysical Research (SOAR)."

UNITED STATES OF AMERICA:

Aaron R. Asrael

(Signature)

Aaron R. Asrael
Grants and Agreements Officer
(Name and Title)

8/31/94
(Date)

NATIONAL SCIENCE FOUNDATION
Arlington, VA

ACCEPTANCE:

X SMonti

(Signature)

STEPHEN A. MONTI
VICE PROVOST
(Name and Title)

SEP 27 1994
(Date)

UNIVERSITY OF TEXAS
Austin, TX

Attachment I

The data stream from each of the aircraft's independent geophysical and navigation systems is collected by a central acquisition computer. A similar system is used to collect base station observations. These acquisition computers, upon recognizing a packet from a particular system, tag it with an identifier and the time from a master clock. This packet is then written in the order of its arrival to an archival medium. At the completion of a flight, these multiplexed data structures both for the aircraft and the base station are demultiplexed and recombined into a hierarchical file structure. This file structure contains a continuous data stream for each aircraft system along each transect and a continuous data stream for each base-station system for the entire flight period. At the completion of the field season the large radar data stream is separated from the other aircraft streams and all transects are spatially gathered. The data streams requested for each proposal/investigator are then archived for distribution.